GROUND-WATER RESOURCE OF NORTHERN OWYHEE COUNTY, IDAHO

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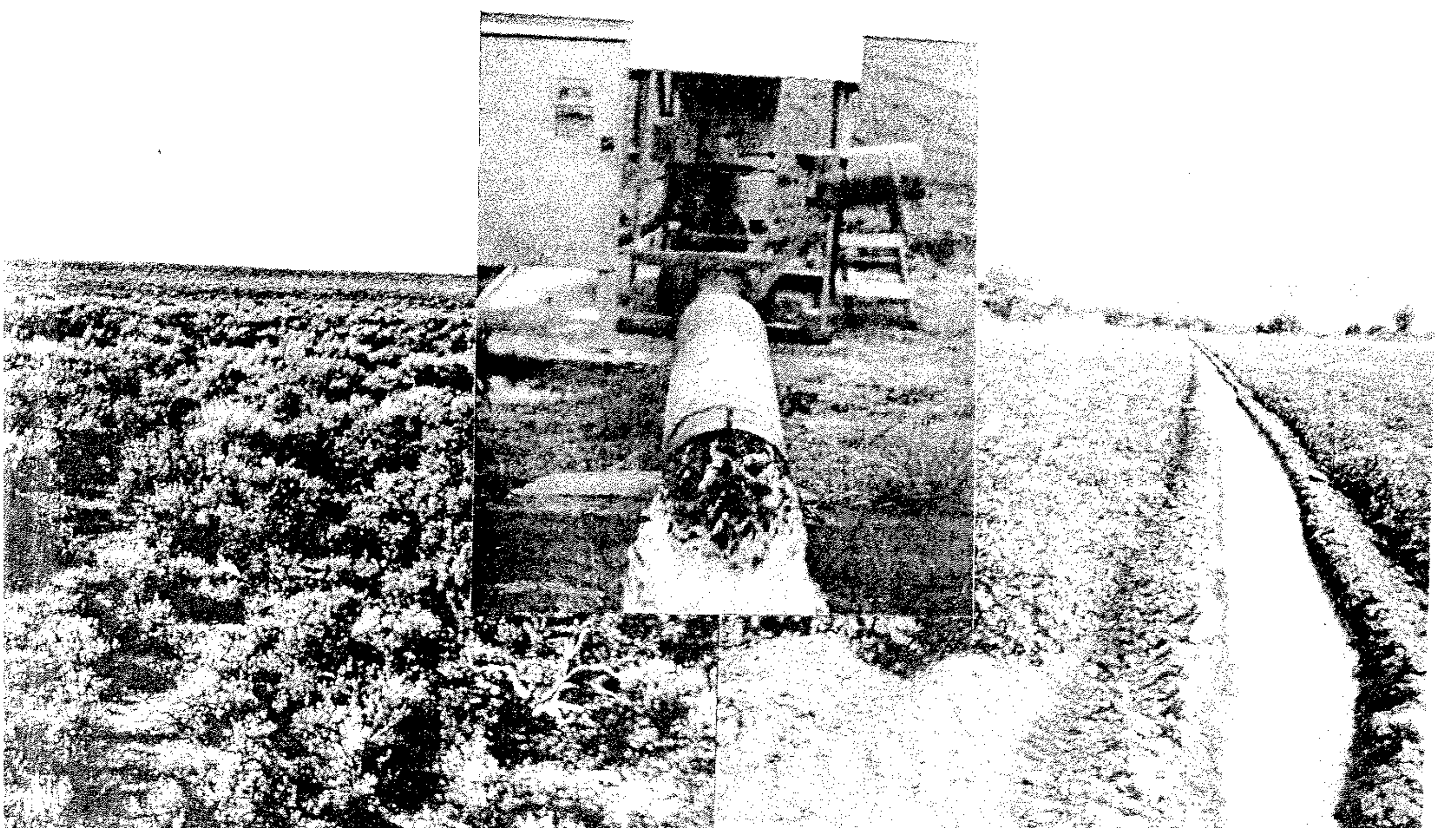

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GROUND-WATER RESOURCE OF NORTHERN OWYHEE COUNTY, IDAHO

by

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CONTENTS

CONTENTS (Cont'd.)

ILLUSTRATIONS

ILLUSTRATIONS (Cont'd.)

ILLUSTRATIONS (Cont'd.)

TABLES

ABSTRACT

The study area in northern Owyhee County includes approximately 2,340 square miles of land in southwestern Idaho. The primary geographic features are the Owyhee Mountains, Owyhee uplift, Snake River canyon and lowland area between the mountains and the Snake River. Ground water is utilized as the primary source of domestic and irrigation supplies over most of the area.

Four geologic formations are most important as aquifers in the study area: Tertiary Silicic Volcanics, Poison Creek Formation, Banbury Basalt and Glenns Ferry Formation. Exposures of the Tertiary Silicic Volcanics and older Tertiary Rhyolites in the Owyhee Mountains and uplift are the primary source areas for recharge to the aquifers in the study area. The silicic volcanics are also an important source of warm to hot, artesian water to wells in several portions of the area. The Poison Creek Formation, a thick sedimentary sequence is utilized to provide warm, artesian water for low-yield domestic and irrigation wells in the western portion of the study area. The Banbury Basalt is the most productive aquifer in the study area. Yields greater than 2,000 gpm have been derived from this unit at depths up to 3,000 feet below land surface. The most extensive aquifer in the study area, the Glenns Ferry Formation, is important primarily as a source of domestic and small scale irrigation supplies. Warm water under artesian pressure is derived from sand interbedded with clay.

The study area was delineated into seven hydrologic subareas. Wells in the Walters Ferry subarea are utilized primarily for domestic purposes. Only a few of the 15 irrigation wells in the area are presently being operated. Wells flow at land surface elevations up to 2,400 feet in the subarea. Major areas of water-level decline have not been noted.

Well development in the Murphy subarea has been very limited. Most of the wells supply water for domestic usage. Water-level declines are not evident from the short record available.

Shallow water-table and deep, artesian aquifers have been utilized for domestic and irrigation supplies in the Oreana subarea. Ten irrigation wells derive hot (130-180°F) water from a deep, artesian aquifer. Twenty irrigation and domestic wells obtain water from a shallower aquifer. Water declines up to 100 feet during the period 1958 to 1968 are evident in the deeper system.

Three aquifers provide water for irrigation and domestic wells in the Grand View subarea: a deep, hot, artesian system, a shallow, warm, artesian system and a shallow, cold, water-table system. The maximum elevation of the piezometric surface in the first two systems is 2,750 and 2,630 feet respectively. Water-level declines averaging 2 feet per year have been noted in the artesian systems.

Seventy irrigation wells have been drilled in the Bruneau subarea, the most intensively developed portion of the study area. Most of the wells obtain warm (90-100°F) water from a deep, artesian aquifer. The maximum elevation of the water surface is 2,700 feet. Water-level declines of one to one and one-half feet per year have been noted in the Little Valley area.

Only limited development of the resource has occurred in the Indian Cove subarea. Domestic supplies are derived from a shallow water-table aquifer and a deep, artesian aquifer. Declines in water levels have not been reported.

Recharge to the aquifers in the study area is from precipitation on the Owyhee Mountains; discharge from the aquifers is believed to be through leakage to the overlying formations and land surface and through wells. The Snake River is not believed to be hydraulically connected to the ground-water system from the C. J. Strike Dam downstream to the edge of the study area.

The quality of the ground water in much of the study area is only fair for irrigation because of a salinity hazard. The ground water is also only fair for domestic purposes because of an excessive fluoride content in portions of the area.

INTRODUCTION

Purpose

The ground-water resource of northern Owyhee County is utilized for domestic and irrigation uses in an otherwise desert region. It is therefore very important in the continuation of the present agricultural prosperity and as a basis for future development. The State Reclamation Engineer has become concerned about the extent to which development should be allowed in the areas where the primary source of ground water is from deep, artesian aquifers. Some declines in water levels have been observed in parts of the area as a result of well development.

The purposes for this study may be stated as follows: 1) to aid the State Reclamation Engineer in administering the present and future water rights within the area, 2) to obtain a greater knowledge of the hydrology and geology of the area in order to assist land owners in developing the resource, and 3) to generally add to the knowledge of the water resources of the State of Idaho.

Objectives

The objectives of the project were to determine the quantity, quality, and occurrence of ground water in northern Owyhee County with special emphasis on the deep, hot, artesian ground water. The more specific objectives were to: 1) determine the geologic control of the ground water in the area, 2) determine the areal extent and hydrologic characteristics of the aquifers, 3) determine the recharge and discharge characteristics of the aquifers, 4) determine the quality and temperature of the ground water and its suitability for domestic and irrigation usages, and 5) denote areas where special consideration is needed in administering the use of the ground-water resource.

Location and Extent

The study area included approximately 2,340 square miles located in the northern portion of Owyhee County (fig. 1). It is bounded on the north by the Snake River, on the west by Squaw Creek, on the east by the range line common to Range 8 East and 9 East, and on the south by the surface water drainage divide and by the township line common to Township 10 South and 11 South.

The field work, conducted during the period of December 1967 through November 1968, included examining geologic formations and collecting well logs and other well data. Four water-level recorders were operated during the study. Ground-water samples from 18 locations were collected and chemically analyzed.

Previous Investigations

The ground-water hydrology has not previously been investigated over a large portion of northern Owyhee County (fig. 2). Littleton and Crosthwaite (1957) studied the ground-water geology of the area from Grand View to Bruneau with special emphasis on the artesian ground-water resource. Crosthwaite (1963) studied the ground-water geology of the Sailor Creek area. Studies of the ground-water geology and hydrology have been completed in the Upper Reynolds Creek watershed by McIntyre (1966) and Stephenson (1965). Recent studies of the geology of other portions of the study area have been completed by Malde and Powers (1962), Malde, Powers and Marshall (1963), Anderson (1965), and Asher (1968).

Well Numbering System

The well numbering system used in this study is the same as that used by the U. S. Geological Survey in Idaho. This system indicates the locations of the wells within the official rectangular subdivisions of the public lands,

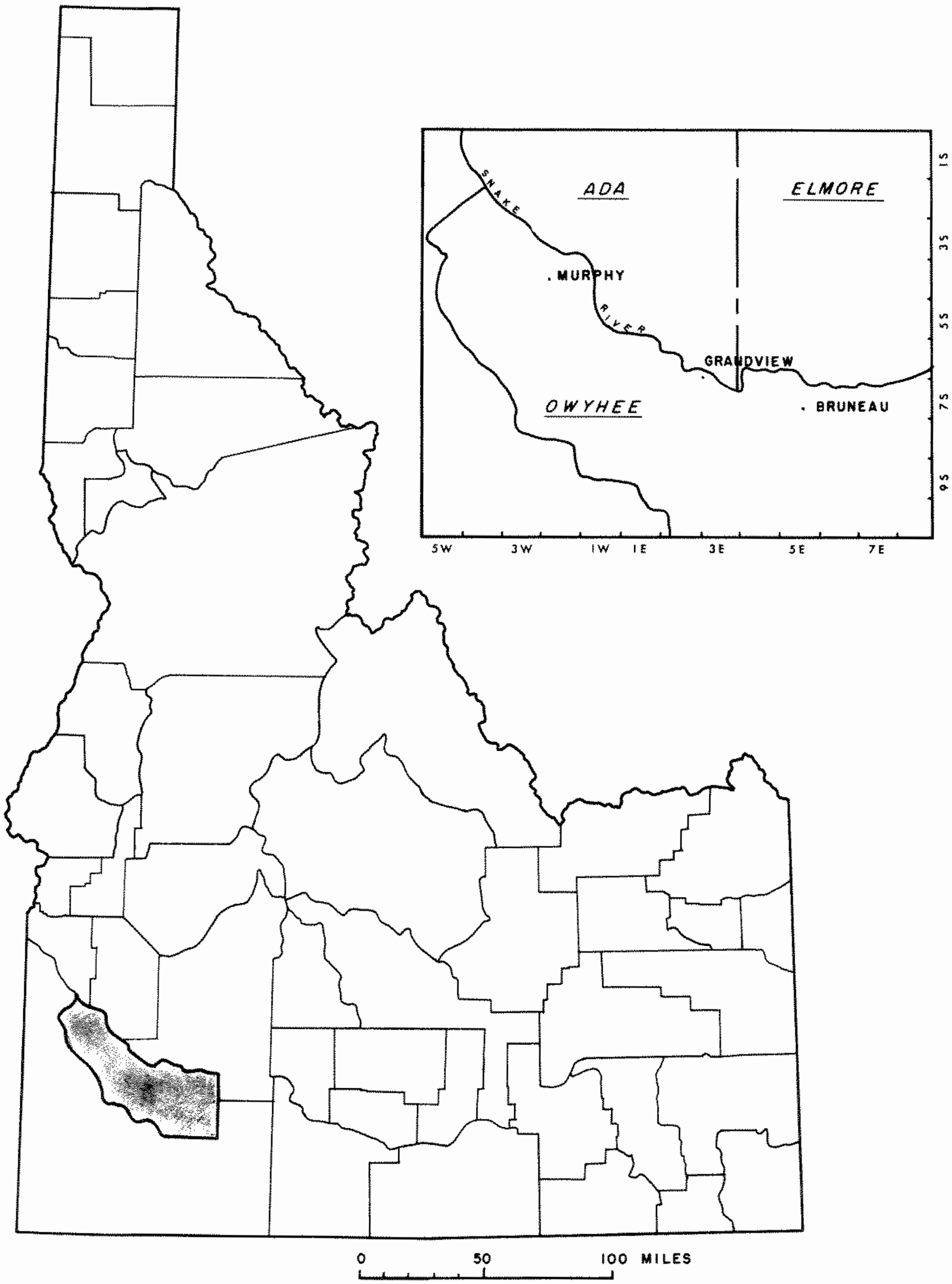


FIGURE 1. Index map showing the area covered by this report

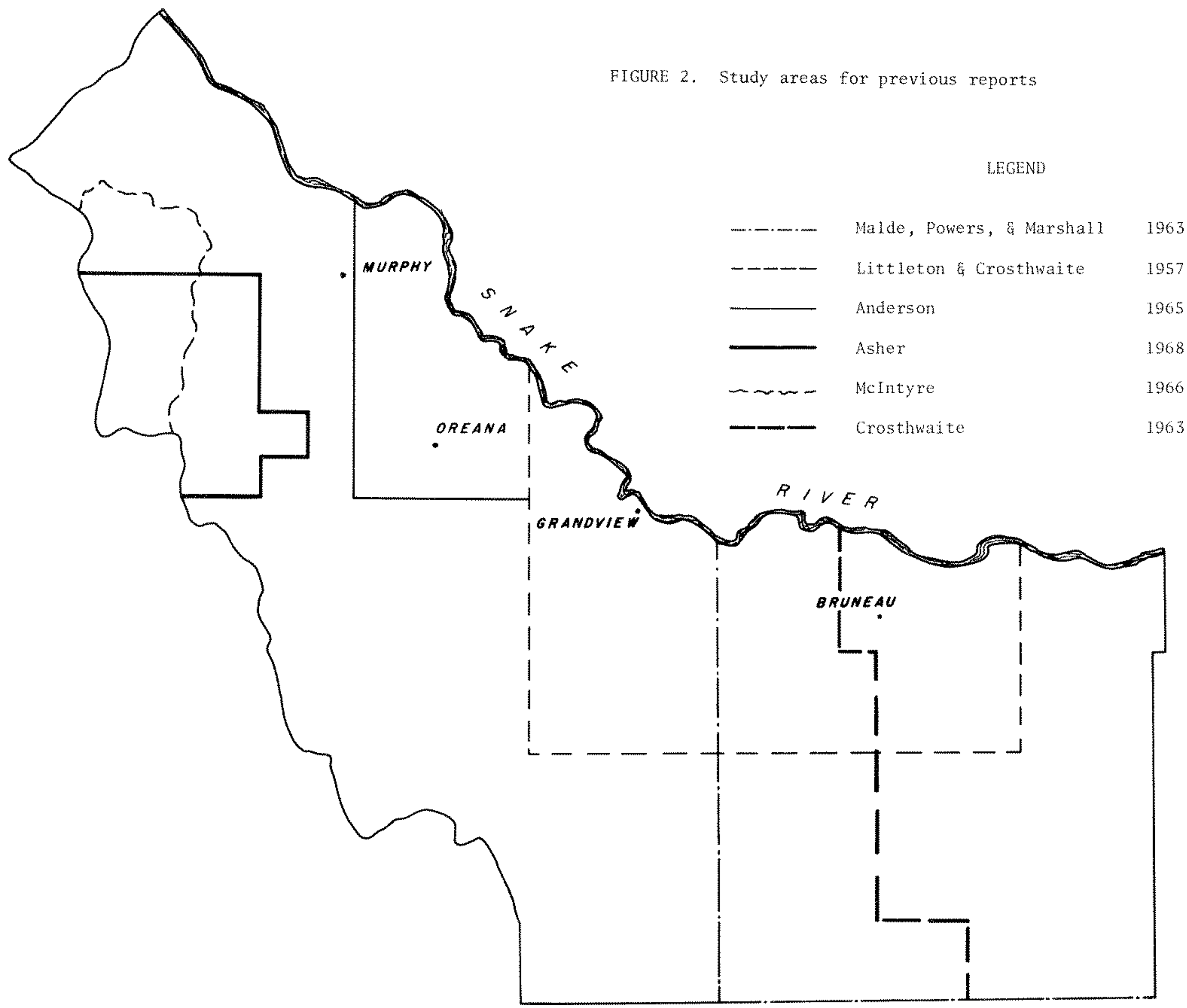


FIGURE 2. Study areas for previous reports

with reference to the Boise Base Line and Meridian. The first two segments of a number designate the township and range. The third segment gives the section number, followed by two letters and a numeral, which indicate the quarter section, the forty-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section (fig. 3). Within the quarter sections, forty-acre tracts are lettered in the same manner. As an example, well 3S 1W 10aa1 is in the NE¼ of the NE¼ of the sec. 10, T. 3 S., R. 1 W., and is the first well designated in that tract.

Geographic Setting

The northern Owyhee County study area is approximately 94 miles long, 25 miles wide and parallels the Snake River (fig. 1). The area consists of four specific geographic features: the Owyhee Mountains, the Owyhee Highland, the Snake River Canyon, and a lowland area between the mountains and the Snake River. The Owyhee Mountains in the southwest portion of the study area are moderate to high relief; mountain peaks rise above 8,000 feet in elevation and canyons several hundred feet deep are common. The mountains grade into an area of moderate relief in the southeastern part of the area. This area, identified as the Owyhee Highland, has not been subjected to such intense deformation and erosion as the mountain range. Deep canyons are present along some of the streams, but mountain peaks higher than 6,000 feet are rare. The lowland area between the Owyhee Mountain front and the Snake River is one of varied relief. Badland topography is prominent near the mountain front. Remnants of a well-developed pediment surface are present at several locations. The Snake River flows along the northern boundary of the study area in a northwesterly direction. It lies in a deep lava canyon through two

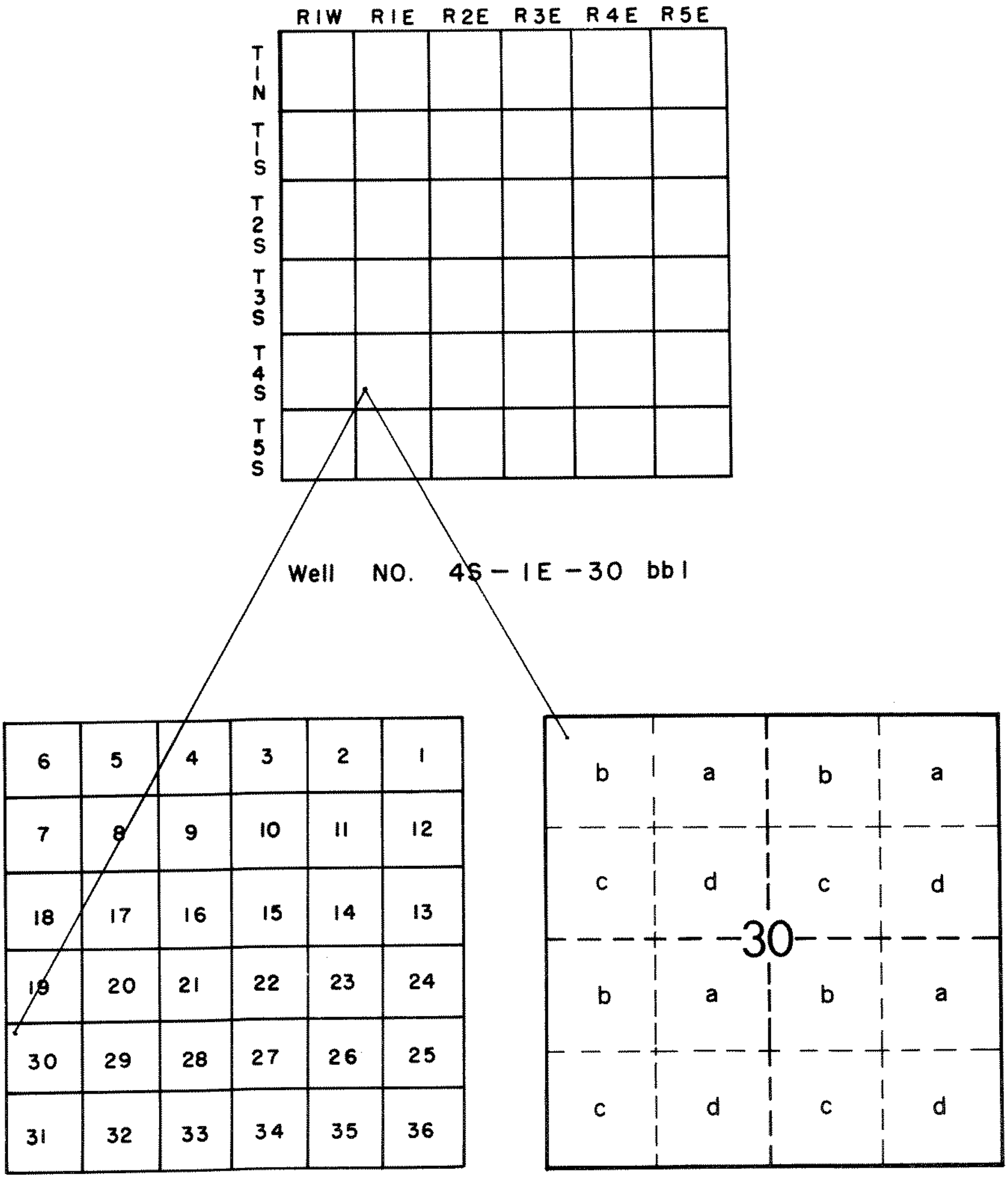


FIGURE 3. Well numbering system

reaches of the river, and a broad valley through the remainder. The river enters the study area in a broad valley in the vicinity of Hammett and is first restricted to a canyon near Indian Cove. The river remains in the canyon to the vicinity of Grand View, where it has cut a broad valley in the weakly resistant sedimentary beds. It reenters a canyon at Jackass Butte and remains there until it reaches the vicinity of Walters Butte. Here, the Snake River has cut a valley several miles wide in the soft sediments. The river flows along the north wall of the valley where a resistant cap of basalt on the sediments has formed a cliff several hundred feet high. The river continues in the valley northwesterly out of the study area.

The main tributary to the Snake River in the study area is the Bruneau River, which is perennial. All of the other streams are ephemeral in their lower reaches and generally flow only during the spring months. Most of these streams have incised deep canyons in the mountains and cut gullies in the lowland area. Springs along the base of the mountains supply small quantities of water to some of the streams, but the flow usually sinks into the ground within a few hundred feet.

The climate of the study area ranges from arid in the lowlands to subhumid in the high mountains. The average monthly precipitation and temperature for eight U. S. Weather Bureau stations nearest the area are shown in table 1. The estimated average precipitation for the lowlands portion of the study area is 8.2 inches. Data from the station at Silver City and isohyetal map of the Upper Reynolds Creek Basin for 1967 (Stephenson, pers. comm.) indicate an average annual precipitation of approximately 15-20 inches for the Owyhee Mountains. The Owyhee Highland receives approximately 10 inches of precipitation per year as shown by the Grasmere and Triangle Ranch stations. The

TABLE 1

AVERAGE MONTHLY PRECIPITATION AND TEMPERATURE

AT STATIONS NEAR THE NORTHERN OWYHEE STUDY AREA

	Swan Falls		Reynolds		Triangle Ranch		Grand View		Bruneau		Grasmere		Glenns Ferry		Silver City
Elevation	2325		3930		5290		2400		2525		5126		2580		6280
Years of Record	31	30	6	6	5	5	29	32	6	6	13	13	44	37	16
Month	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)
January	.97	31.4	.91	28.1	1.27	20.5	.71	29.4	.91	31.3	.46	27.9	1.25	30.0	-
February	.80	38.0	.58	28.7	1.52	30.4	.58	35.4	.92	37.3	.76	31.6	.94	35.0	-
March	.99	44.7	.41	36.8	.97	30.3	.91	43.0	.85	43.1	.36	35.4	1.02	43.0	-
April	.85	50.2	1.02	44.3	1.46	40.9	.70	52.7	1.13	52.4	.98	43.3	.75	52.9	-
May	.95	62.1	1.17	53.3	1.45	48.5	1.09	60.8	.92	59.0	.42	51.4	.90	60.9	-
June	1.29	68.7	2.10	58.8	1.05	56.2	.83	67.9	1.20	64.3	1.47	60.2	.59	66.9	-
July	.24	80.1	1.75	68.3	.29	60.8	.16	76.5	.35	73.5	.33	62.2	.25	75.6	-
August	.08	77.4	.70	66.8	.42	62.6	.11	73.4	.18	71.7	.78	65.5	.14	72.4	-
September	.42	67.3	.34	50.3	.42	53.4	.33	63.5	.41	62.8	1.22	59.4	.25	63.2	-
October	.58	55.9	.78	49.3	.71	43.1	.47	52.3	.57	53.9	.43	49.6	.55	53.3	-
November	.95	41.0	1.30	44.6	.96	37.4	.68	40.3	.84	40.0	1.35	37.7	1.05	40.2	-
December	.68	35.6	1.12	30.1	.42	29.3	.69	29.8	.62	34.6	.80	29.0	.99	33.4	-
Total	8.80		10.48		10.95		7.26		8.90		9.63		8.68		23.14
Average		54.2		47.9		42.7		51.6		52.0		47.7		52.3	

precipitation in the lowlands is evenly distributed from November through June with only a minor percentage falling the summer months. The Reynolds Creek station has the greatest precipitation in June. The average temperature in the lowland varies from 51.0°F at Grand View to 54.2°F at Swan Falls.

Vegetation in the area is typical of a semi-arid environment. Sagebrush, rabbit brush, wheat grass, cheat grass, and many other varieties of low brush and grasses inhabit the lowland area. The Owyhee Mountains exhibit a forest type of vegetation which includes juniper, fir, mountain mahogany, snowbrush, and mountain brome (Asher, 1968, p. 7). Nearly all of the crops in the study area must be irrigated. Some dry land forage is grown along the mountain front. Much of the lowlands adjacent to the Snake River is irrigated by river water. Irrigation water is also diverted from the Bruneau River, Reynolds Creek, and many small intermittent streams. The remainder of the crops grown in the area are irrigated with ground water. Murphy, Oreana, Grand View, and Bruneau are the only settlements in the study area.

GEOLOGY

The northern Owyhee County study area consists of three areas with distinct geologic characteristics: (1) a rugged mountain range in the southwestern portion, (2) a rolling upland in the southeastern portion and (3) a foothill and lowland area extending from the upland and mountainous areas to the Snake River. The mountainous region is composed of a granitic core overlain by younger igneous and sedimentary rocks. The rolling upland is characterized by a mineralized rhyolitic core overlain by a sequence of rocks similar to that of the mountainous region. The foothill and lowland area consists of several poorly consolidated sedimentary formations interspersed with thick sections of basaltic lava. The upland and mountainous regions are important as source areas for recharge to the aquifers in the lowland area. The foothill and lowland areas contain aquifers that have been developed for irrigation and domestic usage in the study area.

Stratigraphy

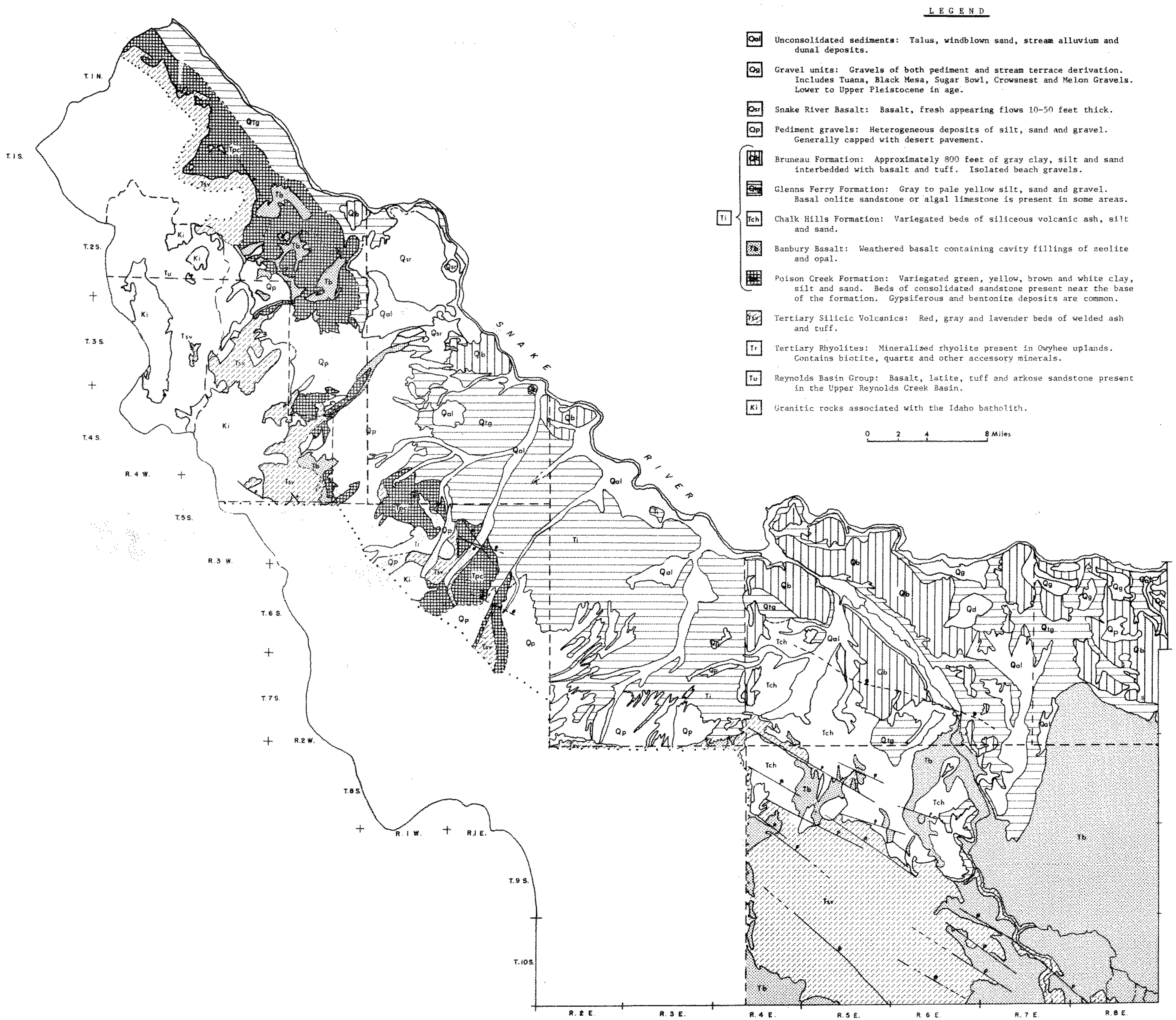
Granitic Rocks

Granitic rocks similar to those present in the Idaho batholith are exposed within the study area (fig. 4). The predominant outcrops are along Upper Reynolds Creek road in T. 2 S., R. 3 W., and along the Murphy-Silver City road in T. 3 S., R. 2 W. These igneous rocks of Cretaceous age are believed to form much of the basement of the study area. This light gray granite is generally unconformably overlain by the Tertiary Rhyolite, Tertiary Silicic Volcanics and Poison Creek Formation and is the oldest unit exposed in the area. Only very limited quantities of ground water may be obtained from joints and fractures in the granitic rocks.

Tertiary Rhyolite

The Tertiary Rhyolite is part of a sequence of mineralized rocks widely exposed in the Owyhee upland. These rocks are differentiated from younger silicic volcanics because of their high degree of mineralization and rhyolitic composition. The Tertiary Rhyolite is reddish-brown in color when weathered and purplish gray when fresh. The formation is highly fractured and exhibits crudely developed columnar jointing. It is Miocene in age and is unconformably overlain by the Tertiary Silicic Volcanics. This unit is important to the ground-water hydrology of the study area only as a source area for recharge to the aquifers in the lowland. No wells are reported to have been developed in these rocks.

FIGURE 4. Geologic map



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Reynolds Basin Sequence

The succession of rocks present in the Upper Reynolds Creek Basin is herein informally defined for this report as the Reynolds Basin sequence. This sequence consists of basalt, latite, silicic tuff, rhyolite, arkosic sandstone, and alluvium. These rocks form a unique series unlike that exposed anywhere else in the study area. The individual units are complexly interbedded and in places, highly faulted. The Upper Reynolds Creek watershed is a study area for hydrologic research by the Agricultural Research Service. Completed work indicates the area approximates a closed ground-water basin (G. Stephenson, pers. comm.). The geology of the area is described in detail by McIntyre (1966). Because of the detailed nature of McIntyre's investigation, no geologic investigation was conducted in the Upper Reynolds Creek watershed for this study.

Tertiary Silicic Volcanics

The Tertiary Silicic Volcanics exposed in the Owyhee Mountains (fig. 4) are believed to be a major source area for recharge to the aquifers in the lowland to the north. The highly jointed and fractured character of the rocks allows vertical and horizontal movement of ground water. The silicic volcanics erode to sheer cliffs and crags several hundred feet high in the Owyhee Mountains and are exposed as rock knobs and in creek canyons in the eastern portion of the area. The base of the unit is not exposed in the study area, but its thickness is believed to exceed 2,000 feet. The most common rocks are mottled gray to lavender welded ash flows. The rocks weather to a reddish-brown color and exhibit well developed vertical and horizontal joints. Malde and Powers (1962, p. 1201) included the silicic volcanic rocks along the margin of the Snake Plain in a unit named the Idavada Volcanics. They identified these rocks as silicic latite and assigned them a stratigraphic position below the Poison Creek Formation. However, the silicic volcanic rocks in northwestern Owyhee County differ both in composition (McIntyre, 1966, p. 156) and physical appearance from the Idavada Volcanics. It is believed that the silicic volcanics are in part interbedded with the Poison Creek Formation. Several well logs indicate penetration of the silicic volcanics and an underlying material identified as the Poison Creek Formation.

Well development in the silicic volcanics has taken place primarily in the Bruneau Valley and Little Valley areas. Deep wells in these areas penetrate as much as 1,270 feet of the unit. Yields to wells in these areas are 1,500 to 2,000 gpm (gallons per minute). Wells deriving water from this formation in the western portion of the study area have much lower yields.

Poison Creek Formation

The Poison Creek Formation (fig. 4) consists of a thick sequence of clay, silt, shale, volcanic ash, and sandstone. Malde and Powers (1962) described exposures of the formation in Owyhee County; Anderson (1965) described the Brown Creek Formation, which is stratigraphically equivalent to the Poison Creek Formation in the Oreana 15 Minute Quadrangle (fig. 5). The formation is best preserved in T. 5 S., R. 1 E., west of Castle Creek, where approximately 250 feet is exposed, and in T. 2 S., R. 3 W., east of the road to the Upper Reynolds Creek Basin, where over 400 feet is exposed. The total thickness of the formation within the study area is unknown, but well 1N 3W 17cc penetrates 700 feet of the unit without reaching the base. The formation is composed primarily of bentonitic silt and poorly consolidated shale. These sediments are variegated yellow, brown, green and gray in color. Outcrops generally exhibit puffy "popcorn" weathering, typical of bentonitic materials.

Geologic Time Scale			Malde & Powers (1962) Formations	Anderson (1965) Formations	Littleton & Crosthwaite (1957) Formations
TERTIARY	Pleistocene	Upper	Melon Gravel Snake River Basalt Crowsnest Gravel Sugar Bowl Gravel	Snake River Basalt Hart Creek Fanglomerate*	Snake River Basalt
		Middle	Black Mesa Gravel Bruneau Formation	Upper member, Jackass Butte Formation, Montini Formation, Otter Basalt	Pediment Gravel*
		Lower	Tuana Gravel		
	Pliocene	Upper	Glenns Ferry Formation	Lower member, Jackass Butte Formation, Oreana Formation	Idaho Formation
		Middle	Chalk Hills Formation Banbury Basalt	Upper member and Sinker Creek Basalt member, Brown Creek Formation	Idaho Formation Basalt of Pliocene(?) age
		Lower	Poison Creek Formation Idavada Volcanics	Lower member Brown Creek Formation Tertiary Silicic Volcanics*	Idaho Formation Silicic Volcanic Rocks
	Miocene	Upper & Middle	Undifferentiated Rocks		Rhyolitic Rocks
			Unconformity		
CRETACEOUS			Granitic Rocks		

*Correlation, tentative or doubtful

FIGURE 5. Equivalent Geologic Formations present in northern Owyhee County

The volcanic ash within the formation forms thin, gray-white interbeds in the silt and shale. These beds are generally not continuous for more than a few hundred yards. The sandstone segment of the formation is best exposed in the western portion of the study area. It consists of numerous beds of impure arkose to subarkose sandstone. The rock is gray to brown when fresh and weathers to reddish-brown and yellow. Bedding is generally thin and cross bedding is common. Most of the sandstone appears to be well cemented, which would decrease permeability. However, many of these sandstone beds have well-developed horizontal and vertical jointing and are highly fractured due to minor subsidence and faulting. The jointing and fracturing might result in a moderate permeability.

The Poison Creek Formation is unconformably overlain by several formations within the study area. The Banbury Basalt overlies and interfingers with the formation throughout the southwestern portion of the study area. Near Murphy and Sinker Creek it is overlain by the Hart Creek Fanglomerate (Anderson, 1965, p. 127). Northwest of Sinker Creek along the Snake River, the formation is overlain by the Glenns Ferry Formation.

The age of the unit has been estimated from various fossil assemblages present within the formation and in overlying formations. Malde and Powers (1962, p. 1203) and Anderson (1965, p. 43) suggest a Lower to Middle Pliocene age for this unit.

The fine-grained nature and the high bentonite content of most of the Poison Creek Formation restricts the yield to wells in the study area. Many wells have penetrated the formation, but rarely yield more than 200-300 gpm. A usable supply of ground water is present only in the sand and fractured sandstone beds. Water present in the formation is generally warm and under artesian pressure.

Banbury Basalt

The Banbury Basalt and equivalent units are exposed throughout the study area (fig. 4). These units have been described by several authors (fig. 5). Littleton and Crosthwaite (1957, p. 161-162) described "Basalt of Pliocene (?) age" which is believed to be equivalent to the Banbury Basalt. Anderson (1965, p. 43-51) described the Sinker Creek basalt member of the Brown Creek Formation which he believes is similar to the Banbury Basalt. The largest areal exposure of the Banbury Basalt is on the Bruneau plateau southwest of the village of Bruneau. Other notable outcrops of basalt equivalent to the Banbury are in Sinker Creek Canyon, T. 3 S., R. 1 W. and near Murphy in T. 2 S., R. 2 W. The thickness of the formation within the study area has been reported as 650 feet south of Hot Spring (Piper, 1924) and 319 feet at well 7S 4E 12bd1 (Littleton and Crosthwaite, 1957, p. 162). Well 2S 2W 36bc1 near Murphy penetrated 750 feet of basalt that is believed to be equivalent to the Banbury. It appears that the Banbury Basalt within the study area was in part deposited contemporaneously with the Poison Creek Formation. Well logs from various localities indicate large amounts of interbedded basalt, clay, and sand. Pillow basalts present in the Sinker Creek Canyon indicate subaqueous deposition for part of the formation.

The Banbury Basalt is black to gray-black in color when fresh and weathers to a reddish-brown. Lenticular interbeds of orange-brown tuff are present in many outcrops. The formation exhibits two major phases of weathering: a relatively fresh appearing phase and a highly altered phase. The most common in the western portion of the study area is the highly altered phase. Many of the outcrops are merely piles of basaltic rubble and sand. Because of the high degree of alteration and cavity filling, this portion of the formation is a poor aquifer. Wells penetrating the basalt in the western portion of the study area generally have low yields.

The second phase of the Banbury Basalt, prominent in the eastern portion of the study area, has not been subjected to such intense alteration. This basalt is black, dense, and generally vesicular. Olivine is present as small rounded crystals and exhibits only minor alteration. Both well-developed columnar and platy horizontal jointings are present. These jointings coupled with the vesicular nature of the rock and cinder zones along contacts of individual flows provide openings for ground-water flow in this portion of the study area. Wells in Little Valley in T. 7 S., R. 5 E., yield as much as 3,800 gpm from this phase of the basalt.

The Banbury Basalt lies upon eroded and faulted Tertiary Silicic Volcanics in the eastern portion of the study area and generally upon the lower part of the Poison Creek Formation in the central and western portions. Where interbedding has taken place, the formation may be overlain by the upper part of the Poison Creek Formation. The Glenns Ferry Formation and the Hart Creek Fanglomerate overlie the Banbury in the central portion of the area; the Chalk Hills, Bruneau, and Glenns Ferry formations overlie it to the east. The age of Banbury Basalt has been determined from fossil assemblages to be Middle Pliocene (Malde and Powers, 1962, p. 1204-1205).

Chalk Hills Formation

The Chalk Hills Formation is exposed in the eastern portion of the study area. Malde and Powers (1962, p. 1205) describe the formation as consisting of silt, sand, and large amounts of siliceous volcanic ash. The rocks are white, brown, pink, and gray in color, resembling the Poison Creek Formation in appearance. Several wells have been drilled in the unit near the upper end of Little Valley. The drillers' logs show 350 to 470 feet of sand and clay, with some gravel, overlying the Banbury Basalt. Yield to wells from the formation is low. The Chalk Hills Formation overlies the silicic volcanic rocks in the southwestern portion of the outcrop area and the Banbury Basalt elsewhere. It has been dated as Middle Pliocene in age on the basis of fossil evidence (Malde and Powers, 1962, p. 1205).

Glenns Ferry Formation

The Glenns Ferry Formation is exposed nearly the full length of the study area. Most of the outcrops are confined to a narrow strip along the Snake River. At least three environments are reflected by the sediments in the formation: fluviatile, lacustrine, and flood plain. These environments are each characterized by particular sediment types and size. The fluviatile or stream environment is indicated by sand, silt, and gravel present in fairly thin beds. Cross-bedding and other indications of running water may be observed in outcrops of the formation. Channel gravels are present at several scattered locations throughout the study area. The lacustrine or lake environment is reflected by deposits of fine sand, silt, and clay in massive beds. Cross-bedding is absent and much of this portion of the unit appears structureless. Some of these lake beds have a high bentonite content which is indicated by a puffy "popcorn" weathered surface. The flood plain environment is not extensive in the study area. It consists of thin dark beds of sand, silt, and clay with some organic matter present. This unit is younger and topographically higher than the other two units.

Near Oreana, beds of oölitic sandstone are present, forming reddish-brown ledges over 150 feet in height. This oölite is believed to have formed where hot springs entered an ancient cold lake. A thick bed of algal limestone occupies a similar stratigraphic position in T. 8 S., R. 6 E., near Indian Bathtub, a hot spring. Both of these units are believed to be basal members of the Glenns Ferry Formation.

The total thickness of the Glenns Ferry Formation in the study area is unknown. Near Guffey Butte the formation is more than 975 feet thick; near Bruneau it is more than 740 feet thick. The formation unconformably overlies the Banbury Basalt and the Poison Creek Formation in the western and central portions of the study area. Near Bruneau and Grand View, the formation overlies the Chalk Hills Formation.

The Glenns Ferry Formation is an important aquifer in the study area. Most of the domestic wells and a few irrigation wells adjacent to the Snake River derive water from this unit. The yield to wells is generally low. However, several wells near Oreana reportedly yield as much as 3,600 gpm from the sand beds in the formation.

The age of the Glenns Ferry Formation has been designated as Late Pliocene or Early Pleistocene on the basis of fossil evidence gathered by Anderson (1965) and Malde and Powers (1962).

Bruneau Formation

Outcrops of the Bruneau Formation are exposed from the eastern boundary of the study area to the vicinity of Guffey Butte (fig. 4). The unit consists of approximately 800 feet of clay, silt, and sand, and a maximum of more than 1,000 feet of basalt (Malde and Powers, 1962, p. 1210). The base of the formation is at approximately 2,450 feet elevation in the vicinity of Bruneau and grades to about 2,700 feet elevation at Hagerman (Malde and Powers, 1962, p. 1210). The sedimentary material in the formation consists of light gray to tan clay and silt with some fine sand. Bedding is generally massive with individual beds often more than 50 feet thick. The sediments of the Bruneau Formation are usually of such a fine grained nature that yields to wells are low. Ground water occurs only in sufficient supply for domestic and stock use.

The basalt of the Bruneau Formation is generally dark gray to black, contains abundant olivine crystals and is quite vesicular. Columnar jointing is well developed throughout most basalt flows. The basalt was emplaced as a series of canyon filling flows originating from a chain of vents roughly parallel to the Snake River. This basalt is more than 1,000 feet thick at Sinker Creek Butte, a dissected vent (Malde and Powers, 1962, p. 1210). Thick beds of water-laid, orange-brown tuff are present between the basalt flows in the Sinker Creek-Murphy area. The Bruneau Basalt has not been observed at any location in the study area west of Guffey Butte. This member of the Bruneau Formation generally lies above the ground-water system. The Bruneau Formation overlies both the Glenns Ferry and the Chalk Hills formations. Fossils identified by D. W. Taylor (Malde and Powers, 1962, p. 1211) suggest a Middle Pleistocene age for the Bruneau Formation.

The Bruneau Formation is not important as a major aquifer in most parts of the study area. Small scale irrigation, stock and domestic wells derive water from the formation in several areas, but the yield to wells is generally low. The only wells that have high yields from the formation are located in sec. 15 and 22, T. 3 S., R. 1 W.

Hart Creek Fanglomerate

The Hart Creek Fanglomerate was described by Anderson (1965, p. 147-157) in the Oreana 15' Quadrangle. It is exposed over an extremely large area and has been interpreted as being a dissected bajada or depositional plain. It has a maximum exposed thickness of 240 feet (Anderson, 1965, p. 148). The formation is composed of silt, sand, and coarse gravel derived from the Owyhee Mountains. The Hart Creek Fanglomerate unconformably overlies several major formations within the study area. These include the Tertiary Silicic Volcanics, the Poison Creek Formation, the Glenns Ferry Formation, the Bruneau Formation, and the Snake River Basalt. The unit has been assigned a post-Middle Pleistocene age on the basis of fossil evidence (Anderson, 1965, p. 153). Occasional small springs are present at the base of the Hart Creek Fanglomerate. The unit, however, is above the general ground-water system within the study area, and is not an important source of water.

Snake River Basalt

The Snake River Basalt is herein considered to include all basalt younger than the Middle Pleistocene within the study area. Outcrops of the basalt are present in the north central portion of the study area near the mouths of Sinker and Rabbit creeks (fig. 4). Sinker and Fossil buttes are capped by the formation. The rock is dark gray to black, plagioclase-olivine basalt. The Snake River Basalt overlies basalt of Middle Pleistocene age in the study area. Northeast of Murphy the basalt unconformably overlies sediments of the Glenns Ferry Formation. Although the unit appears to be very permeable, it is above the general ground-water system.

Gravel Units

The study area contains five major gravel units; the Tuana Gravel, the Black Mesa Gravel, the Sugar Bowl Gravel, the Crowsnest Gravel, and the Melon Gravel. These gravel units range from Lower to Upper Pleistocene in age and occur in widely scattered outcrops. Two of the units, the Tuana Gravel and the Black Mesa Gravel, appear to be remnants of pediment deposits (Malde and Powers, 1962, p. 1209-1212). Two others, the Sugar Bowl Gravel and the Crowsnest Gravel, are remnants of river terraces (Malde and Powers, 1962, p. 1213-1215) which reflect various stages of entrenchment of the Snake River. The fifth, the Melon Gravel, is a gravel deposit emplaced by a catastrophic flood. The gravel units all appear to be very permeable. However, they occur above the regional water table, and are not considered important sources of ground water.

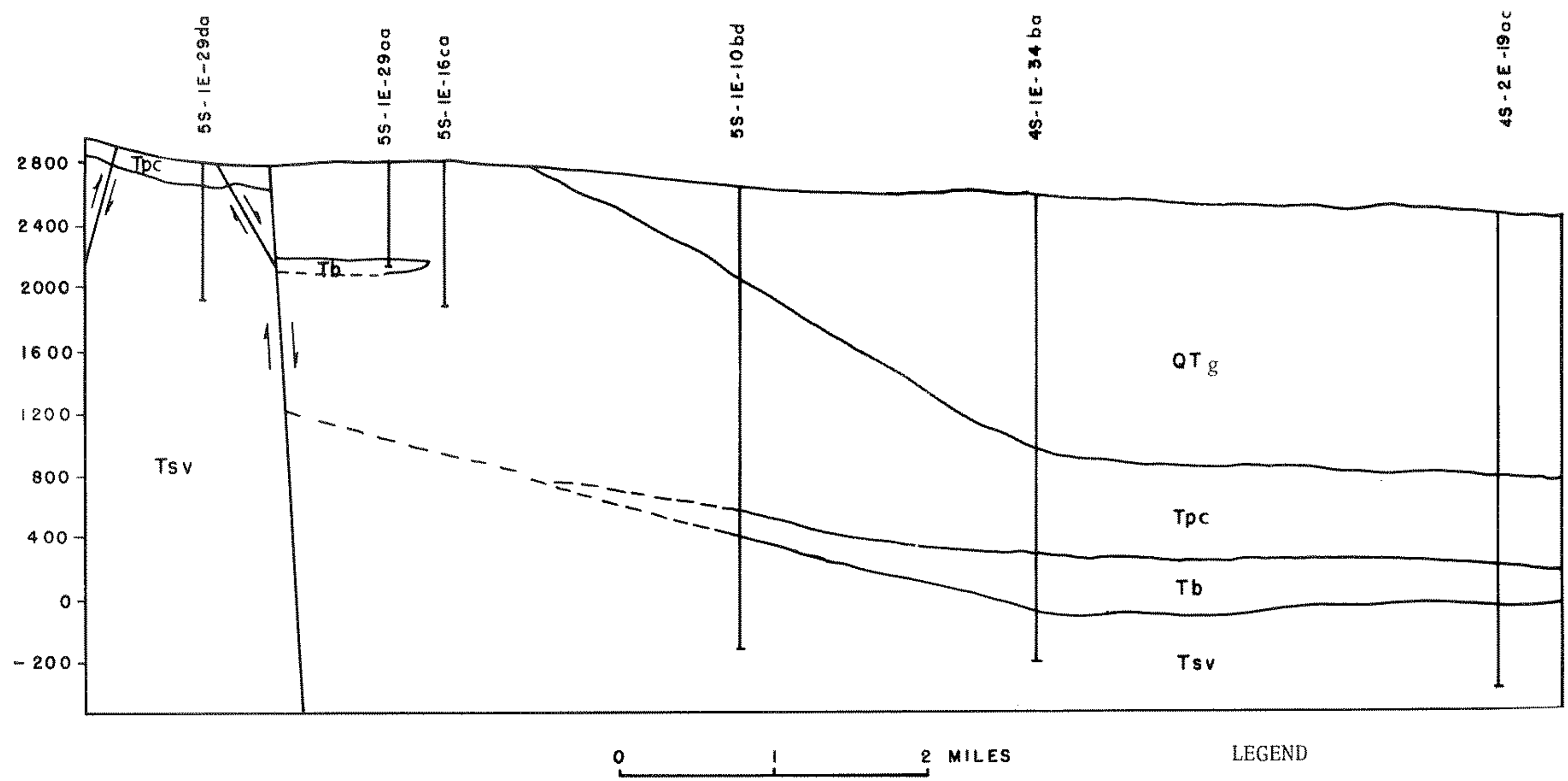
Recent Deposits

Recent deposits in the study area consist of alluvium, talus, and windblown sediments. The type of sediment is directly related to the underlying bedrock. Alluvium is present along the Snake River and the tributary streams as flood plain deposits. Most of the tributary streams have flood plains composed primarily of coarse sand and gravel. Talus slopes are present along the Owyhee Mountain front and the basalt cliffs near the Snake River. Windblown sediments occur in areas underlain by the fine grained sedimentary formations. The most prominent areas of deposition are the Rye Patch north of Oreana and the Sinker Creek flat northeast of Murphy. Much of the rest of the area is covered by thinner deposits of this material. Dunal sand is present in T. 6 S., R. 6 E. These sand dunes are over 400 feet in height and are confined to a relatively small area. A small quantity of ground water is present in the sand, but the material is not considered an important aquifer.

Geologic Structure

The study area is located on the south side of the massive structural feature known as the Snake Plain downwarp. This downwarp is expressed structurally by the gentle (2-3°) northward dip of the younger sedimentary beds and a narrow fault belt along the mountain front (fig. 4). Many of these faults are avenues for ground-water movement; the gently sloping sedimentary beds have given rise to widespread artesian conditions. The faults present in the study area are northwest trending and usually dip from 50 to 80° to the northeast. Movement along the faults has been both lateral and vertical with the north side of the fault generally being the downthrown block. Vertical movement along the fault zones has varied from a few feet to several hundred feet (Littleton and Crosthwaite, 1957, p. 169). The geologic map of the study area (fig. 4) shows some of the faults present along the mountain front. Fault control of ground water is especially evident in the Castle Creek area (fig. 6). Several faults intersect in an area which was once a location of hot springs. Two wells drilled in the vicinity of the intersection of these faults produced hot, artesian water believed to be forced upward in the fault zone. The Hot Spring fault south of Bruneau is another example of fault control of ground water. Hot springs occur along the fault trace, and hot water is believed to be introduced upward through the fault to the artesian aquifer system in Bruneau Valley. This fault cuts the volcanic rocks at depth and as much as 400 feet of displacement has occurred (Littleton and Crosthwaite, 1957, p. 168). Faults present along the mountain front near Hardtrigger, Squaw, and Wilson creeks are believed to provide avenues for the introduction of hot ground water to the aquifers near Givens Hot Springs and Walters Ferry.

Other structural features in the area are associated with volcanic eruption. Basalt dikes are present at several locations, primarily north and west of Murphy. Several volcanic necks are present along the Snake River. No evidence has been found to indicate that these volcanic structures have a significant effect on ground-water movement within the study area.



LEGEND

Qtg Glenns Ferry Formation

Tpc Poison Creek Formation

Tb Banbury Basalt

Tsv Tertiary Silicic Volcanics

FIGURE 6. Geologic cross section in the Castle Creek Valley

Cenozoic Geologic History

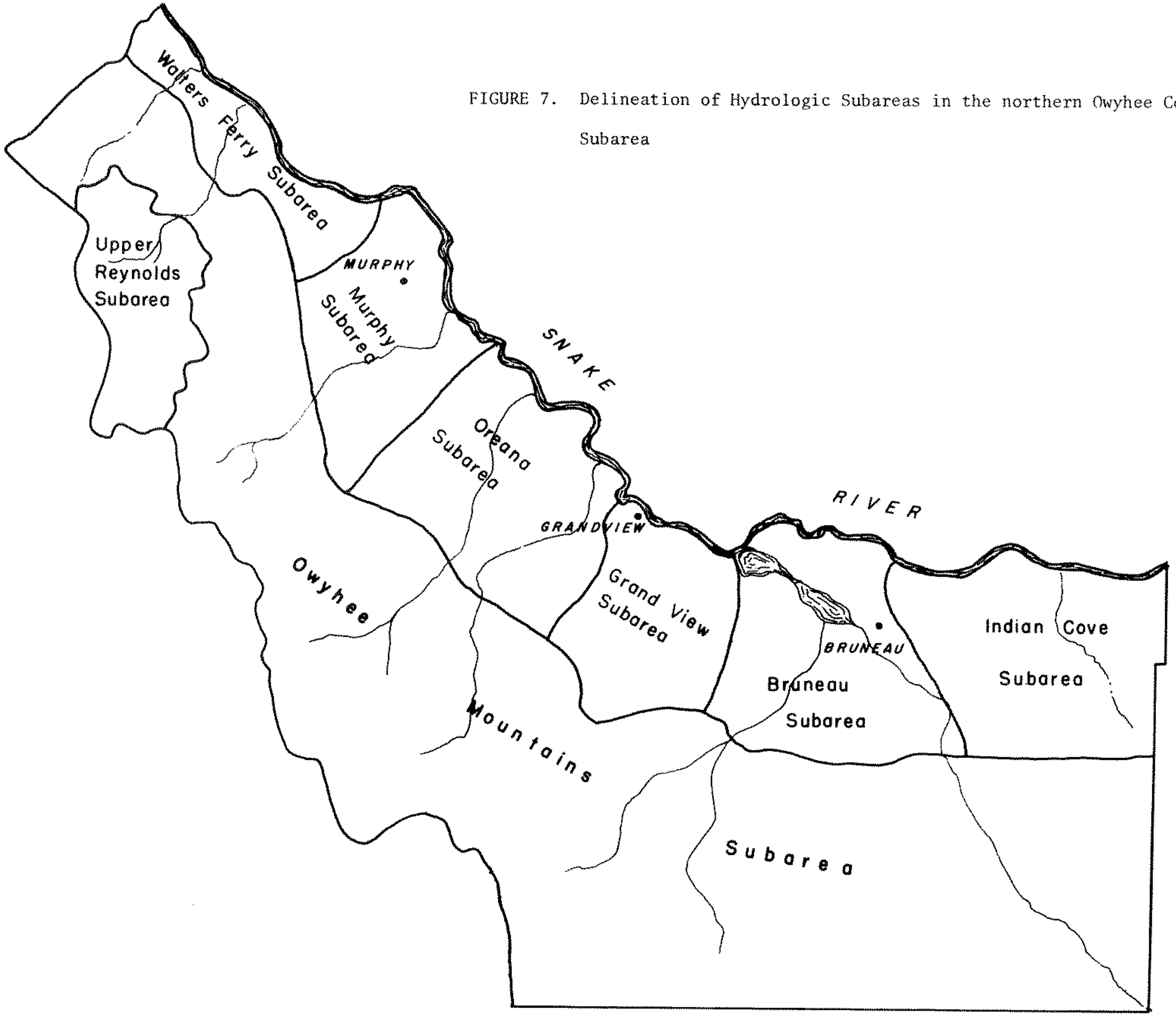
During the Late Miocene and Early Pliocene, large volumes of silicic volcanic rocks were extruded on a highly eroded topography along the axis of the Owyhee Mountains. During the late stage of eruption, intense tensional stresses caused major faulting along the present Owyhee Mountain front. Deposition of a thick sequence of clay, silt, and sand began in an extensive, shallow lacustrine environment in the western portion of the study area. Silicic eruption continued sporadically resulting in some interbedding. Subsidence and faulting continued along northwest trend lines. Basalt was extruded from widely separated vents during the Middle Pliocene. Large volumes of the basalt were deposited on the silicic volcanics southeast of Bruneau. Vents near Sinker Creek and Rabbit Creek erupted into the shallow lakes and ponds and became interbedded with the sedimentary sequence being formed. Erosion during Upper Pliocene time created a hummocky topography. Encroachment of a large lake began during the uppermost Pliocene. Granitic silt and sand, volcanic ash, and basaltic sand were deposited in the lake which extended from east of Hagerman to beyond the western border of Idaho. After several thousand feet of these sediments had accumulated, erosion again began. Deep canyons and gullies were cut into the soft sediments. Basalt erupted from a series of vents roughly parallel to the present course of the Snake River filling many of the canyons and gullies and damming the Snake River at several locations. Fine grained sediments filled many of the small lakes that were formed. A vent at the mouth of Sinker Creek was buried by these sediments. As deposition slowed, the Snake River began cutting its channel to its present level. A large pediment formed along the Owyhee Mountain front and many older geologic features were exhumed. Another short volcanic episode occurred at this time, primarily north of the study area. The lava extruded was very fluid and covered much of the area north of the Snake River adjacent to the study area. Recent deposition in the area consists of talus slope deposits, terrace gravel and alluvium along streams and accumulation of thin deposits of windblown sand and silt in the flatter areas. Flood plains are presently being formed along the Snake River and a few of the larger tributary streams.

HYDROLOGY

Delineation of Hydrologic Subareas

The study area was divided into eight subareas to facilitate the discussion of the hydrology. The delineation of the subareas was based on variations in ground-water hydrology and the pattern and type of well development. The Owyhee Mountains subarea includes the southern half of the study area and is essentially devoid of well development. The primary geographic features of the subarea are the Owyhee Mountains and Owyhee Highland. (See fig. 7 for subarea boundaries.) The Upper Reynolds Creek subarea includes the southern portion of the Reynolds Creek Basin. This area was delineated as a subarea because it is believed to be a closed ground-water basin. The subarea has been designated as the Northwest Hydrology Research Watershed by the Agricultural Research Service, U. S. Department of Agriculture. Considerable research into the ground-water characteristics of this area has been accomplished by the A.R.S. The Walters Ferry subarea includes the ground-water development along the south bank of the Snake River from Squaw Creek to Guffey Butte in the western portion of the study area. The Murphy subarea includes a large, relatively undeveloped area in the west central portion of the study area. Wells have been drilled in scattered locations for domestic and irrigation uses, but a

FIGURE 7. Delineation of Hydrologic Subareas in the northern Owyhee County Subarea



major development of the resource has not occurred. The ground-water development in and near the Castle Creek valley is included in the Oreana subarea. Water-level decline and well interference have been noted in both the shallow and deep aquifers in this area. The Grand View subarea includes the Shoofly Creek valley and the area along the Snake River near Grand View. Both shallow and deep aquifers have also been developed in this area. The most intensively developed areas of ground-water irrigation are included in the Bruneau subarea. This subarea, in the eastern portion of the study area, includes Little and Bruneau valleys. A deep aquifer has been extensively developed by irrigation wells, many of which flow under artesian pressure. The Indian Cove subarea includes the remaining portion of the eastern part of the study area. The ground-water development in this area has been primarily domestic and stock wells.

The ground-water hydrology of the above mentioned subareas is discussed in detail in the following sections. Particular emphasis is placed on the description of the aquifers, discussion of the present well development and its effect upon the resource, direction and the characteristics of ground-water flow and water quality.

Owyhee Mountains Subarea

The Owyhee Mountains subarea is important primarily as a recharge area for the aquifers underlying the lowlands to the north. The boundaries of the subarea are the range line common to R. 8 and 9 E. on the east, Squaw Creek on the west, the drainage divide and the township line common to T. 10 and 11 S. on the south, and the approximate mountain or upland front on the north (fig. 7). Climatalogical data presented in table 1 indicate an average annual precipitation rate of about 15 inches for the subarea.

The surface runoff from the Owyhee Mountains subarea is divided into many ephemeral streams. The only perennial stream in the subarea, the Bruneau River, derives most of its flow from the Jarbidge Mountains to the south. The ephemeral streams of importance include: Squaw Creek, Reynolds Creek, Sinker Creek, Castle Creek, Jacks Creek and Wickahoney Creek. Wickahoney Creek and Bruneau River are the only streams gaged in the study area. Wickahoney Creek flows only after periods of excess precipitation or snowmelt. The average discharge for 12 years of record is 2.2 cfs (cubic feet per second). The Bruneau River is gaged at Hot Spring where it leaves its deep canyon and enters the lowland. This stream had an average discharge of 377 cfs during the 29 year period of record. Small channels in the subarea carry flood discharge after periods of precipitation.

Water is recharged to the ground-water system in the Owyhee Mountains subarea through joints, faults and other structural features in the rocks. Two formations, the Tertiary Rhyolite and Tertiary Silicic Volcanics, are believed to be most effective in transmitting recharge water to the ground-water system. Both of these formations are highly fractured in most of the outcrop areas. Recharge is believed to occur both areally and locally where stream channels cross areas of intense fracturing. These rocks outcrop over approximately 40-50 per cent of the Owyhee Mountains and nearly all of the Owyhee uplift. The potential for areal recharge is therefore high. Littleton and Crosthwaite (1957, p. 172) state that the entire normal flow of Jacks and Wickahoney creeks is absorbed by the rocks in a faulted complex along Jacks Creek. Quantitative assessments of the amount of water recharged in the Owyhee subarea have not been determined.

Ground-water development is limited in the Owyhee Mountains subarea. Several stock wells have been drilled at high elevations, but yield only small quantities of water. Intensive ground-water development is not expected in the subarea.

Upper Reynolds Creek Subarea

Ground water is used in the Upper Reynolds Creek subarea almost exclusively for domestic purposes. Most of the wells are less than 50 feet in depth and obtain water from channel alluvium. Several irrigation wells have been drilled to a maximum depth of 1,000 feet in the subarea. These wells are presently unused. The transmissibility values obtained by Stephenson (1965, p. 458) indicate that most of the aquifers in the subarea would support only low production wells (transmissibility values of less than 50 gallons/day/foot). Problems of well interference, water-level declines, or decreases in well yields, have not been reported in the subarea. The present well development has not appreciably altered the ground-water resource.

Walters Ferry Subarea

The ground-water resource in the Walters Ferry subarea is important primarily as a source for domestic water supplies. Although a few irrigation wells are in production, most of the water used for irrigation is diverted from the Snake River or Reynolds Creek. Most wells that have been drilled in the area generally obtain only small to moderate supplies of water.

Ground water in the Walters Ferry subarea is believed to be derived primarily from precipitation in the Owyhee Mountains. The water, recharged to the ground-water system in the mountains, flows northward toward the Snake River.

Four geologic formations that may be important as aquifers in the Walters Ferry subarea are the Tertiary Silicic Volcanics, Poison Creek Formation, Banbury Basalt, and Glenns Ferry Formation. Tertiary Silicic Volcanics are encountered in several deep wells near the mountain front. Only small quantities of water have been obtained because, in most cases, the drillers stopped shortly after encountering what is believed to be the formation. The evaluation of the Tertiary Silicic Volcanics as an aquifer in this area thus cannot be completed at this time because of the absence of sufficient data.

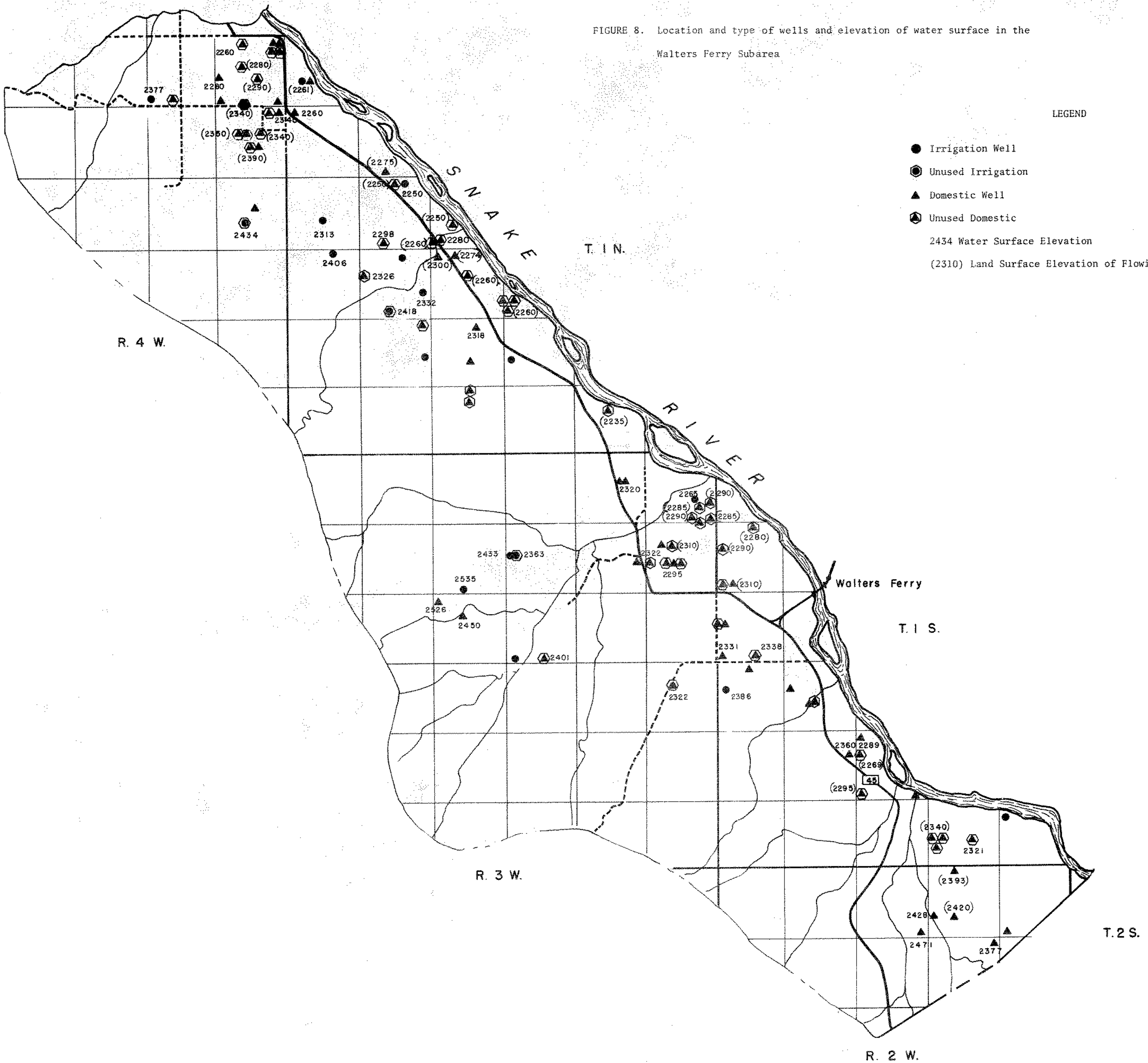
The Poison Creek Formation is the most widespread aquifer in the subarea. The deeper wells that tap this formation encounter warm to hot water under artesian pressure. Thick beds of clay and silt provide the aquiclude or capping layer that confines the artesian aquifer. The water is generally derived from sand or sandstone beds. Because the horizontal permeability is much greater than the vertical permeability, water encountered in different sand zones often has different temperatures and artesian pressures. The yields to wells from this formation are generally low to moderate.

The Banbury Basalt is an important aquifer only in isolated locations in the Walters Ferry subarea. The formation is limited in areal extent and also varies widely in permeability. Most of the drillers' logs indicate that only small quantities of water were derived from this formation.

Wells near the Snake River which penetrate the Glenns Ferry Formation yield warm to hot water under artesian pressure. The domestic and small irrigation wells that derive water from this unit generally have only low to moderate yields.

Wells in the Walters Ferry subarea are used for both domestic and irrigation water supplies. Unused flowing wells are also present in the area (fig. 8). In many cases, the domestic supplies are from two- to four-inch diameter flowing wells drilled prior to 1930. The warm (80-100^{o}F) ground water is used

FIGURE 8. Location and type of wells and elevation of water surface in the Walters Ferry Subarea



LEGEND

- Irrigation Well
- Unused Irrigation
- Domestic Well
- Unused Domestic

2434 Water Surface Elevation

(2310) Land Surface Elevation of Flowing Well

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in several cases for heat as well as consumption. The depths of most of these wells are unknown. Newer domestic wells have been drilled in several locations. Most of these wells are less than 200 feet deep and have low yields.

Approximately 15 irrigation wells have been drilled in the Walters Ferry subarea (fig. 8). These wells supply irrigation water for lands higher than the surface water distribution system. They vary in depth from 155 to 2,860 feet. The yields of most of the wells are low with only a few presently being operated.

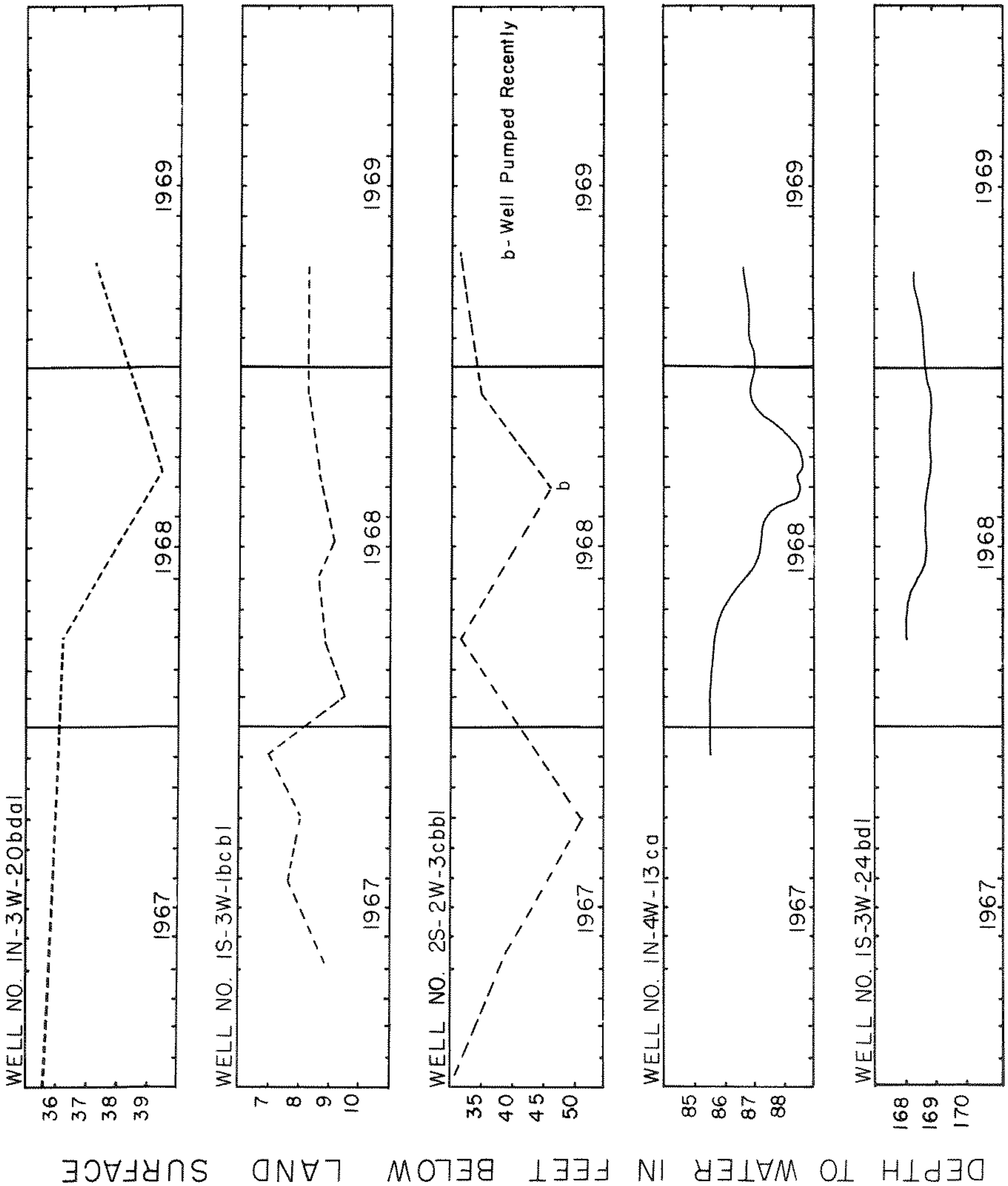
Many small diameter wells drilled prior to 1930 are allowed to flow uncontrolled and waste water in the Walters Ferry subarea. These wells were drilled in the sediments of the Glenns Ferry and Poison Creek formations until the small rotary drill rigs were stopped by a hard layer. All of these wells are thus believed to derive their water from the sediments of the two upper formations. The water from these wells range in temperature from 70 to 135°F. It is believed that the temperature of the water is dependent on the depth of the well and the formations encountered. The total flow of all of the wells of this type represent a significant portion of the total ground-water discharge in the subarea. The locations of the wells of this type visited during the study are shown on figure 8.

The elevation of the water surface in non-flowing wells in the Walters Ferry subarea is also presented in figure 8, along with the land surface elevations at wells that flow under artesian pressure. Wells flow at land surface up to elevations of 2,350 feet in the western portion of the subarea, 2,300 feet in the central portion, and a maximum of 2,400 feet in the eastern portion of the area. A variation in artesian pressure is evident in wells of different depths. The data showing elevation of water surface indicate ground-water flow is from the mountains northward toward the river. Sufficient data are not available, however, to determine the gradient and configuration of the ground-water surface.

Most of the Walters Ferry subarea has not undergone a major ground-water decline as a result of well development. Records of water level fluctuations are available on several wells in the subarea. A 2,860 foot well (1N 4W 13ca1) and a 1,540 foot well (1S 3W 24bd1) were monitored during the investigational period. This record is presented in figure 9 along with a short water level record on three wells monitored by the U. S. Geological Survey. None of the hydrographs indicate a significant change in water levels. The decline noted in the hydrograph of well 1N 4W 13ca1 is the result of pumping an irrigation well approximately 1,000 feet from the observation well. The relatively flat and constant slope of the recovery curve is an indication of the slow rate of recharge to the area.

Although not documented by water-level record, one portion of the subarea has undergone a water-level decline in the magnitude of 20 to 30 feet. The area of decline includes wells in sec. 16-17, 20-21, and 28-29, T. 1 N., R. 3 W. A well in sec. 20, T. 1 N., R. 3 W. had a reported depth-to-water of 24 feet in 1962 and a measured depth-to-water of 48 feet in 1968. A well in sec. 29, T. 1 N., R. 3 W., that had flowed since it was drilled in 1903, stopped flowing in 1961. The spring supplying the Givens Hot Springs Resort in sec. 21., T. 1 N., R. 3 W., has reportedly declined in discharge in the last five years. Details on the rate or pattern of water-level decline in this area are not available. Several wells in sec. 34, T. 1 S., R. 2 W. have been the subject of a court decree. These wells were drilled in a small area and mutual interference occurred. This interference, however, is a local problem and not a case of

FIGURE 9. Hydrographs of wells 1N 4W 13ca1, 1S 3W 24bd1, 1N 3W 20bda1, 1S 3W 1bcb1 and 2S 2W 3cbb1 in the Walters Ferry Subarea



regional water-level decline.

The quality of the ground water in the Walters Ferry subarea is generally good. The dissolved solids content ranges from 200-330 ppm (parts per million). The water is primarily of sodium or calcium bicarbonate type with several analyses very high in fluorides.

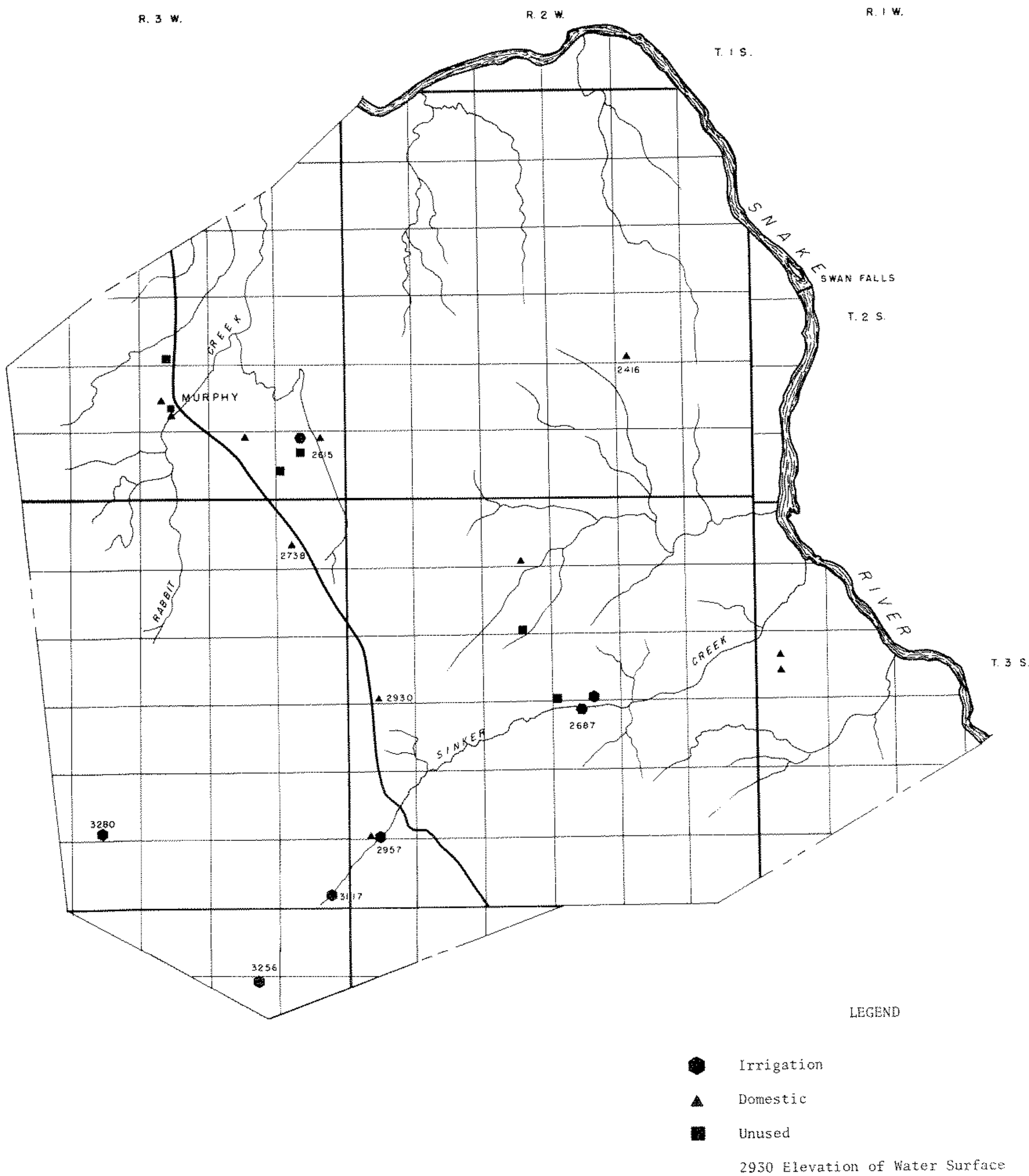
Murphy Subarea

The ground-water resource has been developed for irrigation and domestic supplies at only scattered locations in the Murphy subarea. Less than 25 wells are located in the area. Most of these are used for domestic supplies and yield only small quantities of water. The source of ground water in the Murphy subarea is believed to be precipitation on the Owyhee Mountains. The quantity of ground-water recharge originating within the subarea from local precipitation or irrigation return flow is believed to be small.

Four geologic formations are important as aquifers in the Murphy subarea: Poison Creek Formation, Banbury Basalt, Glenns Ferry Formation, and Bruneau Basalt. None of the wells in the area encounter the silicic volcanics. Wells penetrating both of the Banbury Basalt and the Poison Creek formations derive most of their water from the basalt. One well derives water from a sandstone lense in the Poison Creek Formation. Several wells which penetrate thick sections of Glenns Ferry Formation near the Snake River yield only small quantities of warm (70-90^{o}F) water under low artesian pressure. Wells in the Sinker Creek valley in sec. 15 and 22, T. 3 S., R. 1 W., penetrate and derive water from Bruneau age basalt.

The well development has been limited in the Murphy subarea. The only large tract of irrigated land is supplied by water pumped from the Snake River. The location of wells in the Murphy subarea are shown in figure 10. Most of

FIGURE 10. Location and type of wells and elevation of water surface in the Murphy Subarea



the irrigation wells presently in use are in the Sinker Creek valley. The yields from these wells vary from 200 to 1,400 gpm with the higher yields being obtained from the wells in sec. 15 and 22, T. 3 S., R. 1 W. The elevation of the water surface for wells in the Murphy subarea is presented in figure 10. Sufficient data are available to make only a very general interpretation of ground-water flow. The data indicate flow from the mountains toward the river.

Water-level records have been obtained for three wells in the Murphy subarea. An unused irrigation well (2S 2W 36bd1) was monitored continuously during 1968 (fig. 11). The decline shown in the hydrograph is believed to be primarily the result of operation of an irrigation well in the same section. Although the irrigation well was turned off for the season in September, significant water-level recovery did not begin in the observation well until middle November. This lag in recovery is believed to be an indication that the aquifer in that area is limited in areal extent and has a low rate of recharge. Water levels in wells 3S 1W 8cbc1 and 4S 2W 11aba1, monitored by the U. S. Geological Survey, changed only 2 feet and 0 feet respectively from the spring of 1967 to the spring of 1968. Water-level decline or well interference have not been reported in the area.

The temperature of the ground water in the Murphy subarea ranges from 70 to 90°F. The quality of the ground water ranges from poor from the sediments to good from basalt.

Oreana Subarea

The Oreana subarea includes the ground-water development near Oreana and that in and near the Castle Creek valley (fig. 7). Two major aquifer systems are important in the subarea. (1) A number of irrigation and domestic wells near Oreana derive water from a series of shallow sand beds in the Glenns

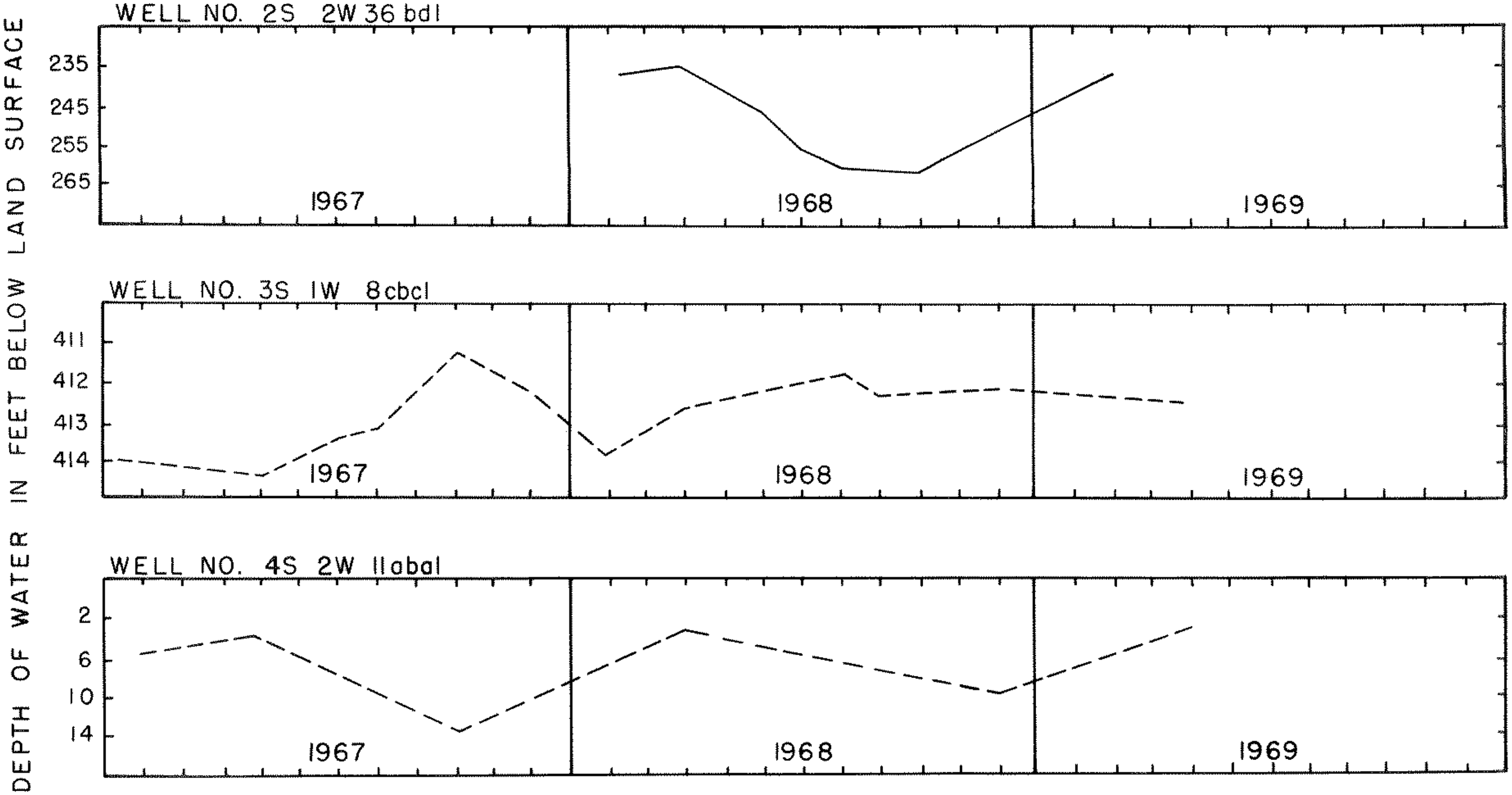


FIGURE 11. Hydrographs of wells 2S 2W 36bd1, 3S 1W 8cbc1 and 4S 2W 11aba1 in the Murphy Subarea

Ferry Formation. (2) Hot (130-180°F) ground water under high artesian pressure is obtained by a number of wells in the Castle Creek valley from the Banbury Basalt and the Poison Creek Formation.

The ground water in the Oreana subarea is believed to be derived primarily from precipitation on the Owyhee Mountains. Although some recharge reaches the shallow aquifer from local precipitation and irrigation, the total quantity is believed to be small.

The four geologic formations that may be important as aquifers in the Oreana subarea are, from youngest to oldest; the Glenns Ferry Formation, Poison Creek Formation, Banbury Basalt, and Tertiary Silicic Volcanics. A sequence of coarse grained sediments are present in the Glenns Ferry Formation near Oreana at depths of 200-300 feet below land surface. The lateral extent of these coarse grained sediments is inferred in figure 12 from the surface outcrops and the drillers' log data. A number of irrigation and domestic wells obtain water from this aquifer near Oreana. The formation is also utilized as an aquifer in the Castle Creek valley by both shallow wells (less than 50 feet) and old 2- to 4-inch diameter flowing wells. The deeper wells derive small quantities of warm (70-100°F) water under artesian pressure.

The Poison Creek Formation is generally a poor source of water in the Oreana subarea. Some of the old 2- to 4-inch wells which penetrate the Glenns Ferry Formation also penetrate the Poison Creek Formation. These wells yield only small quantities of warm water under artesian pressure. A portion of the hot, artesian water encountered in the deep wells in the Oreana subarea may be derived from the Poison Creek Formation.

The Banbury Basalt is important as the source of hot (130-180°F), artesian water in the Oreana subarea. This formation is encountered by most of the deep

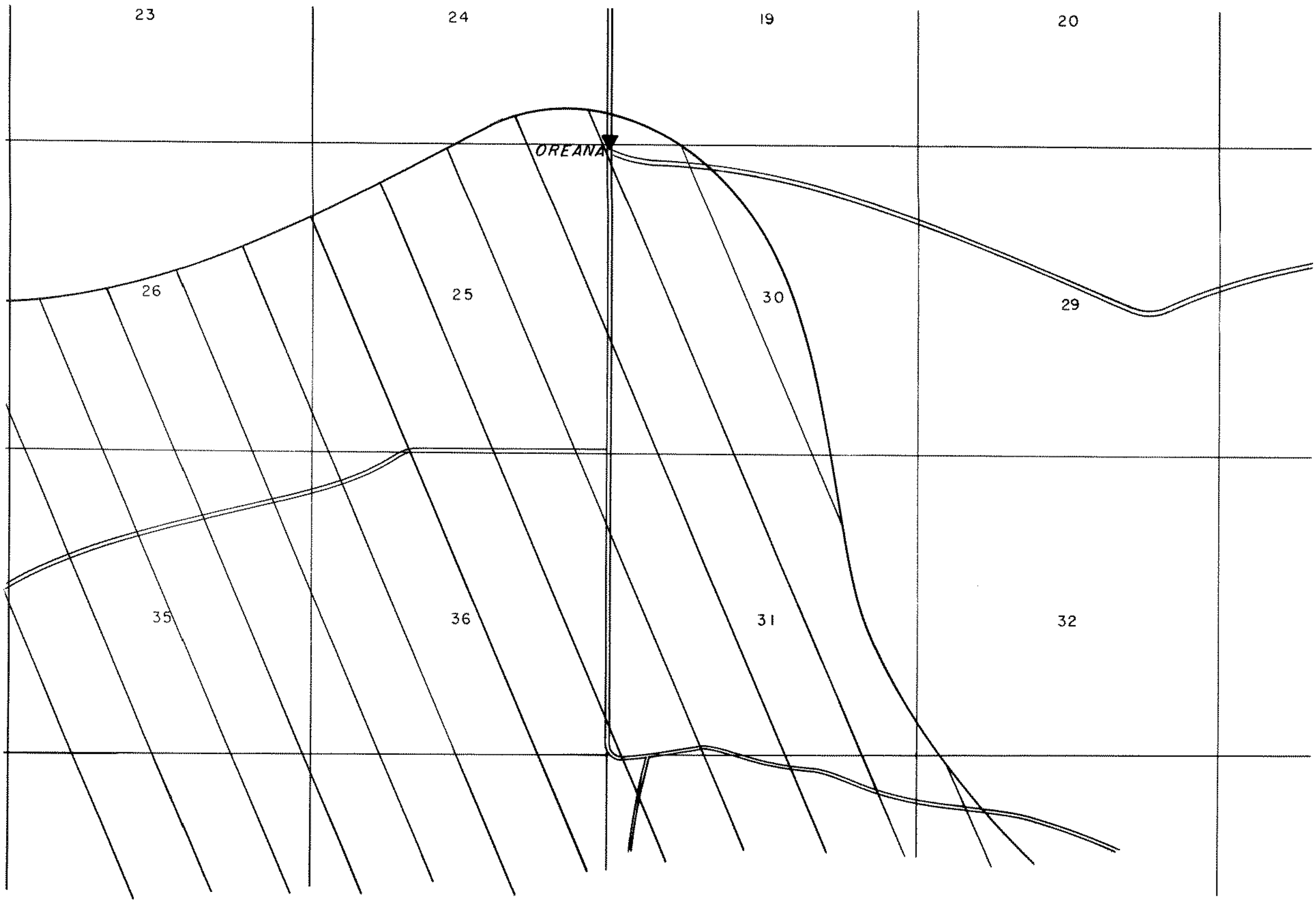


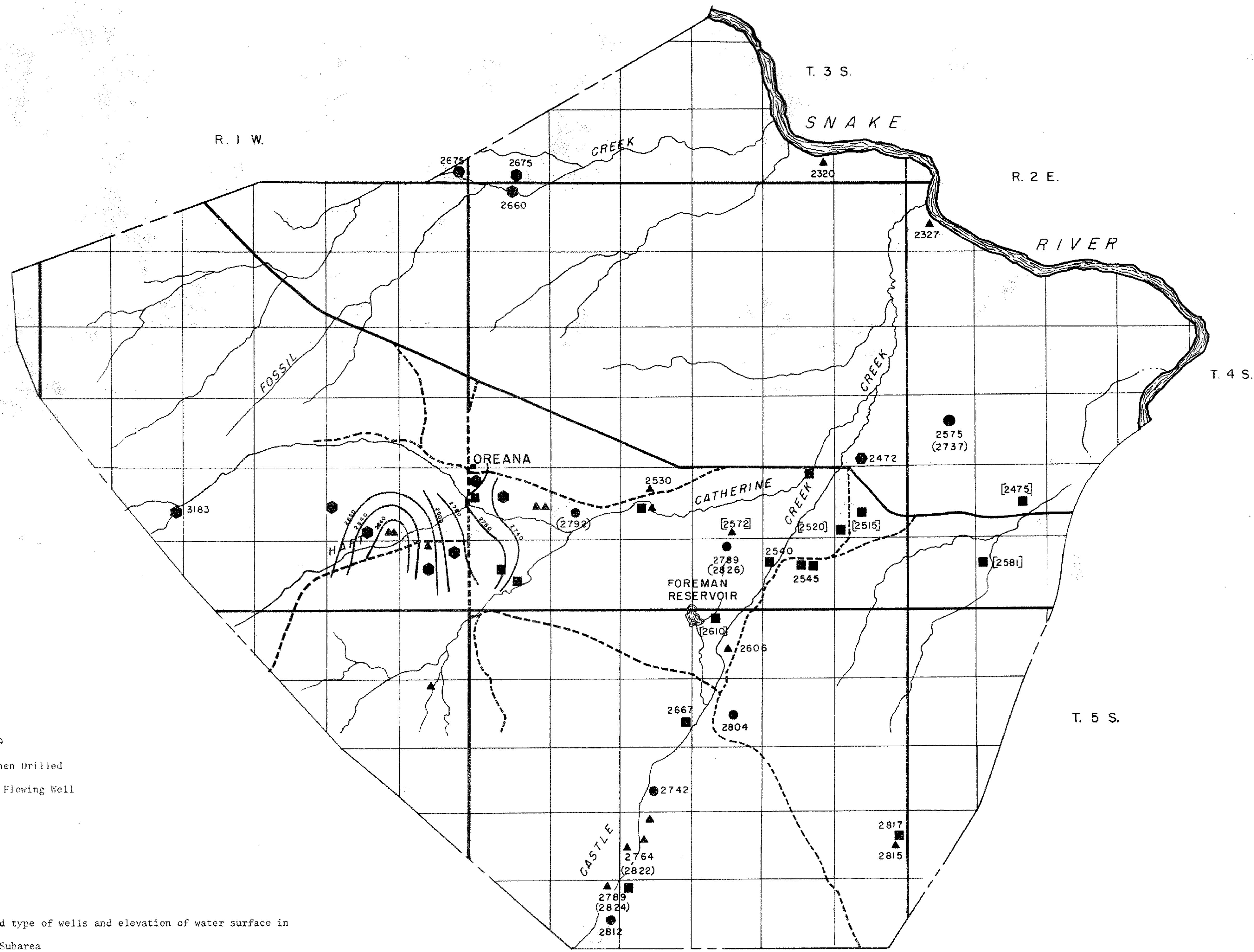
FIGURE 12. Extent of the sand aquifer in the Oreana area

wells in the area.

The silicic volcanics are penetrated by several wells in the Oreana subarea. The data from these wells do not indicate that a significant quantity of water is derived from the formation. The importance of the silicic volcanics as an aquifer in this area cannot be determined at this time because of a lack of data.

The well development in the Oreana subarea may be divided into the following three categories on the basis of use and source of the water: hot, artesian wells, pumped irrigation and domestic wells, and unused flowing wells (fig. 13). Ten wells, ranging in depth from 660 to 3,100 feet, have intercepted hot (130-180^{o}F) ground water under high artesian pressure. All of the wells flowed under artesian pressure when drilled. Discharges greater than 7.5 cfs were reported. The hot, artesian water is obtained at depths over 2,500 feet in the northern portion of the Oreana subarea, but at only 600 feet in sec. 21 and 29, T. 5 S., R. 1 E. The difference in the depth to the artesian aquifer is believed to be the result of vertical displacement along a northwest trending fault or faults. These same faults are believed to provide avenues for the upward movement of the hot water. A former hot spring area near Castle Creek in sec. 29, T. 5 S., R. 1 E. is the location of the intersection of two of these faults (fig. 6). The artesian pressure in wells indicate an original piezometric surface near 2,800 feet elevation.

Approximately 20 irrigation and domestic wells are equipped with pumps in the subarea. Most of these wells were drilled near Oreana and derive water from the coarse sand beds in the Glenns Ferry Formation. The wells vary in yield from a few gallons per minute to 1,900 gpm. The depth to water in all of the wells is less than 200 feet with most less than 100 feet. The temperature



LEGEND

- Hot Artesian Wells
- Pumped Irrigation Wells
- Domestic Wells
- Unused Wells

2764 Elevation W.S. 1969

(2822) Elevation W.S. When Drilled

(2610) Elevation L.S.D. Flowing Well

FIGURE 13. Location and type of wells and elevation of water surface in the Oreana Subarea

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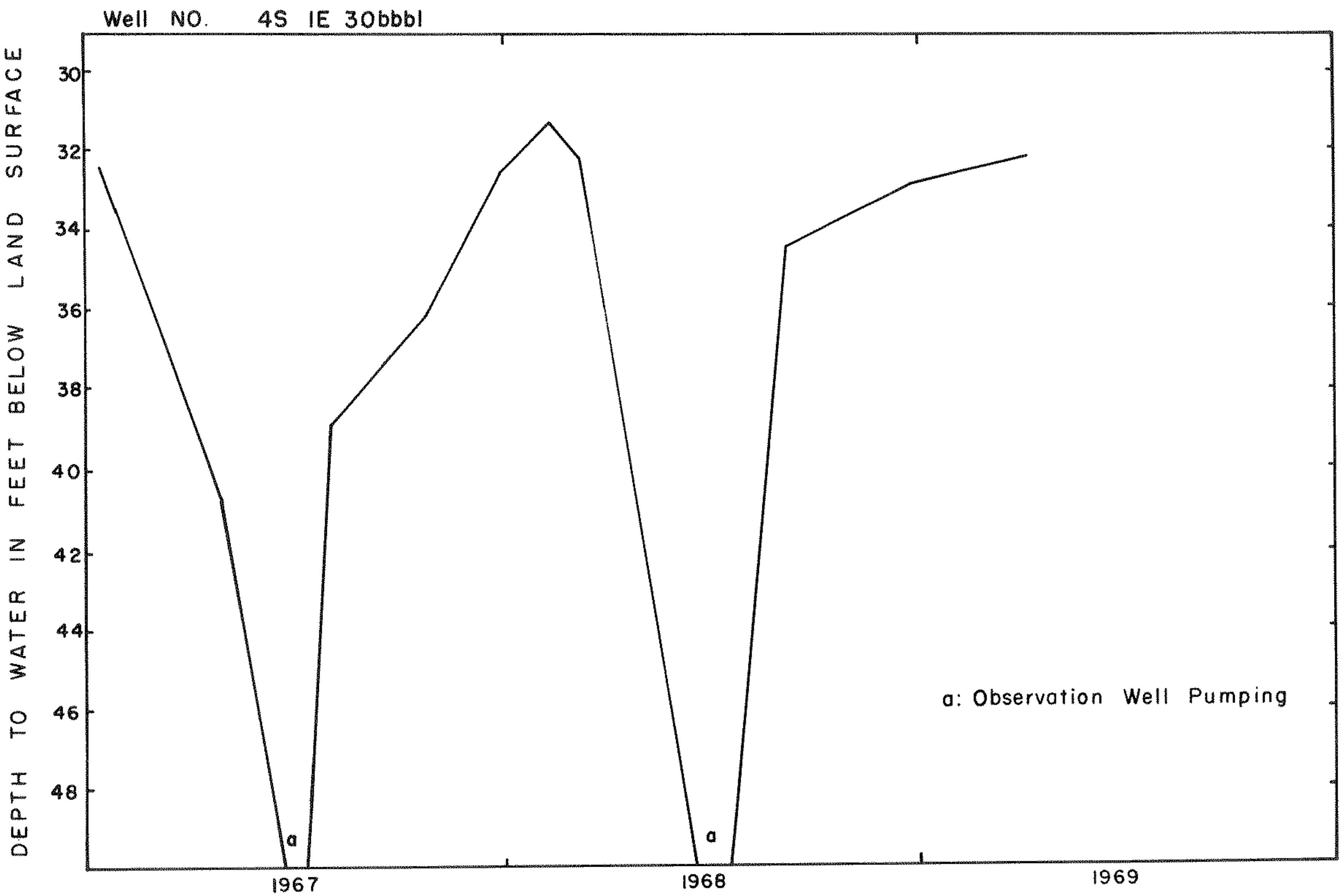
of the water derived from these wells ranged from 55 to 70°F.

The third type of wells in the subarea are the unused small diameter flowing wells drilled prior to 1930. Although construction data are not available on these wells, they are assumed to have been drilled entirely in sediments. Most of these wells flow at land surface at temperatures of 70-100°F. Several shallow wells (less than 50 feet) have been drilled in the Castle Creek valley for domestic purposes. Two irrigation supplies have been developed by excavating large holes approximately 20-30 feet deep and pumping the ground water that collects. The pits are probably obtaining water from stream alluvium connected directly or indirectly with Castle Creek.

The elevation of the water surface in wells in the Oreana subarea is presented in figure 13. Contours of water-level elevation are presented in the vicinity of Oreana. The contours indicate ground-water flow from the west to the east with a gradient of approximately 60 feet per mile. The movement of ground water cannot be traced farther to the northeast because of the lack of well development. Some interference between wells and a seasonal decline in water levels have been reported near Oreana. The short hydrograph record available on well 4S 1E 30bb1 (fig. 14) does not indicate a significant yearly decline in water levels in the area

Two elevations are noted on figure 13 for wells tapping the hot, artesian ground-water system. The upper values noted are the original levels of artesian pressure when the wells were drilled. The lower values are the fall, 1968 levels. The original head value of the first well (5S 1E 21cb) tapping the hot water system was 2,822 feet. The original levels on all but one of the remainder of the wells was in the range of 2,790 feet to 2,825 feet, indicating that the piezometric surface was originally very flat or near 2,820

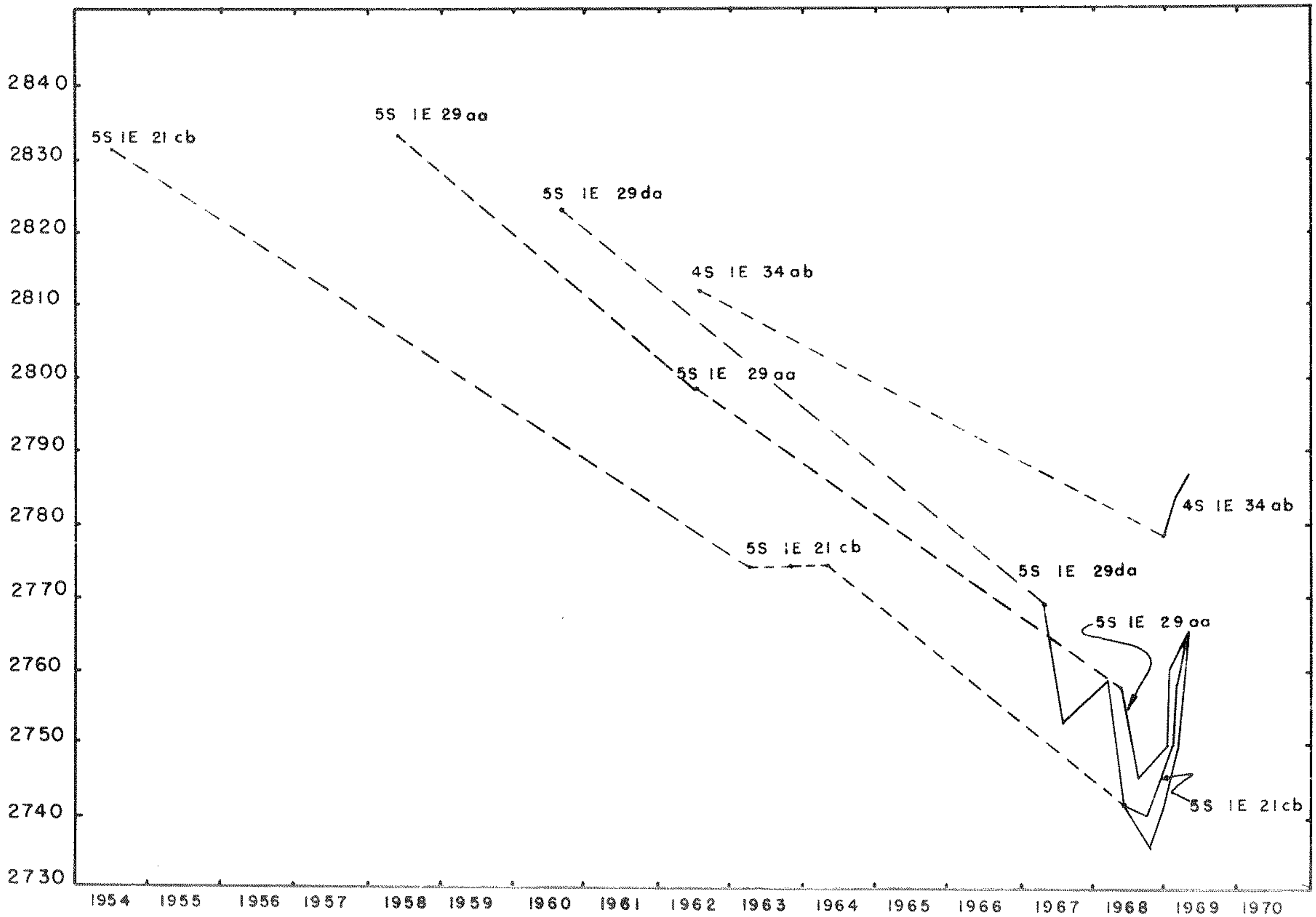
FIGURE 14. Hydrograph of well 4S 1E 30bb1 in the Oreana Subarea



feet elevation. The well in sec. 19, T. 4 S., R. 2 E. had an original water level elevation of 2,737 feet. The head difference indicates that this well either penetrates a different aquifer system, or another aquifer system in addition to the one common to the other hot wells. The range in temperature in the wells from 136 to 178^{o}F is probably the result of mixing of colder water with the hot water either in the well or in the aquifer.

The water levels in the hot, artesian aquifer system began declining as soon as wells were drilled and began to withdraw water. Details of the rate of decline are scarce with only scattered data available (fig. 15). At least 100 feet of water level decline has occurred in well 5S 1E 29aa from 1958 to 1968. The pattern of this decline is only documented for the period 1967-69. Declines of 80 and 90 feet can be noted in other wells. The levels in the two wells in sec. 24, T. 5 S., R. 1 E. have not apparently undergone the same rate of decline as the remainder of the wells in the aquifer. The increase in the rate of recovery in the wells that can be noted in January 1969 is the result of the closure of a formerly uncontrolled flowing well (4S 1E 34ba1). This well formerly flowed over 7.5 cfs throughout the year. Some of the decline, suffered in the hot, artesian system, is expected to be reversed by the closure of this well. The artesian pressure in the aquifer, however, will not return to its original level with the closure of the single off season waste of ground water. The recharge-discharge relationship was in equilibrium prior to the drilling of wells in the area. The natural discharge at that time included spring flow, evapotranspiration by plants near the springs and leakage into overlying aquifer systems because of the leaky characteristics of the overlying confining layers. The well development in the area has caused a decline in piezometric pressure and has decreased and thus captured a portion

FIGURE 15. Hydrographs of wells 4S 1E 34ab1, 5S 1E 21cb, 5S 1E 29aa and 5S 1E 29da in the Oreana Subarea



of this natural discharge. A quantitative assessment of the total recharge to the hot, artesian system cannot be completed until the leakage to other aquifers is determined. This determination is beyond the scope of this report.

The quality of ground water in the Castle Creek subarea is generally good. The total dissolved solids varies from 250 ppm in the hot, artesian system to 150 ppm in the aquifer near Oreana. The water is predominately a sodium and calcium bicarbonate type. Concentrations of 1-3 ppm fluorides are present in the hot ground water.

Grand View Subarea

The ground-water resource in the Grand View subarea has been developed for domestic supplies along the Snake River and for domestic and irrigation supplies in the valley regions south of the river. Three major aquifer systems are important in the Grand View subarea: a hot, artesian system in the Tertiary Silicic Volcanics and the Banbury Basalt, a warm, artesian aquifer system in the sediments of the Idaho Formation and a cold, water-table aquifer system in the alluvium and an upper portion of the Idaho Formation.

Ground water in the deep aquifers in the Grand View subarea is believed to be derived primarily from precipitation on the Owyhee Mountains and uplift. The Tertiary Rhyolite and silicic volcanics are believed to transmit the water from the mountainous regions to the subarea. Most of the recharge to the overlying Banbury Basalt and Idaho Formation is from leakage upward from the silicic volcanics. Some water is recharged to the ground-water system from the streams flowing over highly fractured outcrops of the Banbury Basalt. Recharge to the shallow aquifer near the Snake River is more directly from precipitation, seepage from canals, irrigation and sewage effluent.

Four geologic formations that may be important as aquifers in the Grand View subarea are the Tertiary Silicic Volcanics, Banbury Basalt, Idaho Formation, and alluvium. The silicic volcanics are encountered by several wells in the area at depths from 2,000 to 3,000 feet. The drillers' logs from most of the wells indicate that water was obtained from the formation. The yields obtained from the silicic volcanics cannot be determined because these wells also obtain water from the overlying formations. The importance of the formation as an aquifer in this area thus cannot be assessed at this time.

The Banbury Basalt is the most important aquifer within the Grand View subarea. This formation is encountered in wells at depths ranging from 600 to 2,000 feet below land surface. Irrigation wells tapping the Banbury Basalt yield up to 2,500 gpm when pumped and 750 gpm by artesian flow. The temperature of water obtained from the formation ranges from 125 to 150°F. The permeability of the basalt varies widely in the subarea. Very dense flows within the formation can act as confining layers.

Most of the wells in the Grand View subarea derive a portion of their water from the Idaho Formation. The wells that derive water from only the Idaho Formation generally have low yields and lower artesian pressure than those wells penetrating the underlying Banbury Basalt. Irrigation wells derive up to 750 gpm from the formation; water temperature is generally within the 70-100°F range.

The third aquifer system important in the Grand View subarea is the alluvium found along the major stream channels. Many wells less than 50 feet in depth obtain domestic supplies from the alluvium and the upper portion of the Idaho Formation near Grand View. In most cases, they intercept water in the alluvium that does not percolate downward because of the general low vertical permeability of the Idaho Formation. The yields obtained from the shallow aquifer are sufficient for domestic and small irrigation uses.

The well development in the Grand View subarea may be divided into three major categories on the basis of source and use: shallow domestic, irrigation, and unused flowing wells (fig. 16). Most of those near the Snake River in the Grand View subarea are less than 50 feet deep and are used for domestic purposes. Many wells near the the town of Grand View have a potential water quality problem. The same sand and gravel layers are used for both sewage disposal and water supply. The present system of individual water supplies should be abandoned in favor of a single deeper source of ground water.

Approximately 20 irrigation wells are being operated in the Grand View subarea (fig. 16). Most of these are located several miles south of the Snake River at higher elevations than the surface-water distribution system. The depth of the wells vary from 100 feet to 3,600 feet. Approximately half of the wells were drilled deep enough to intercept the hot (125 to 150°F), artesian ground-water system. Several yield up to 2,500 gpm. A number of shallow irrigation wells obtain lesser quantities of water at temperatures ranging from 80 to 125°F. The maximum reported yield of the shallow wells is 750 gpm.

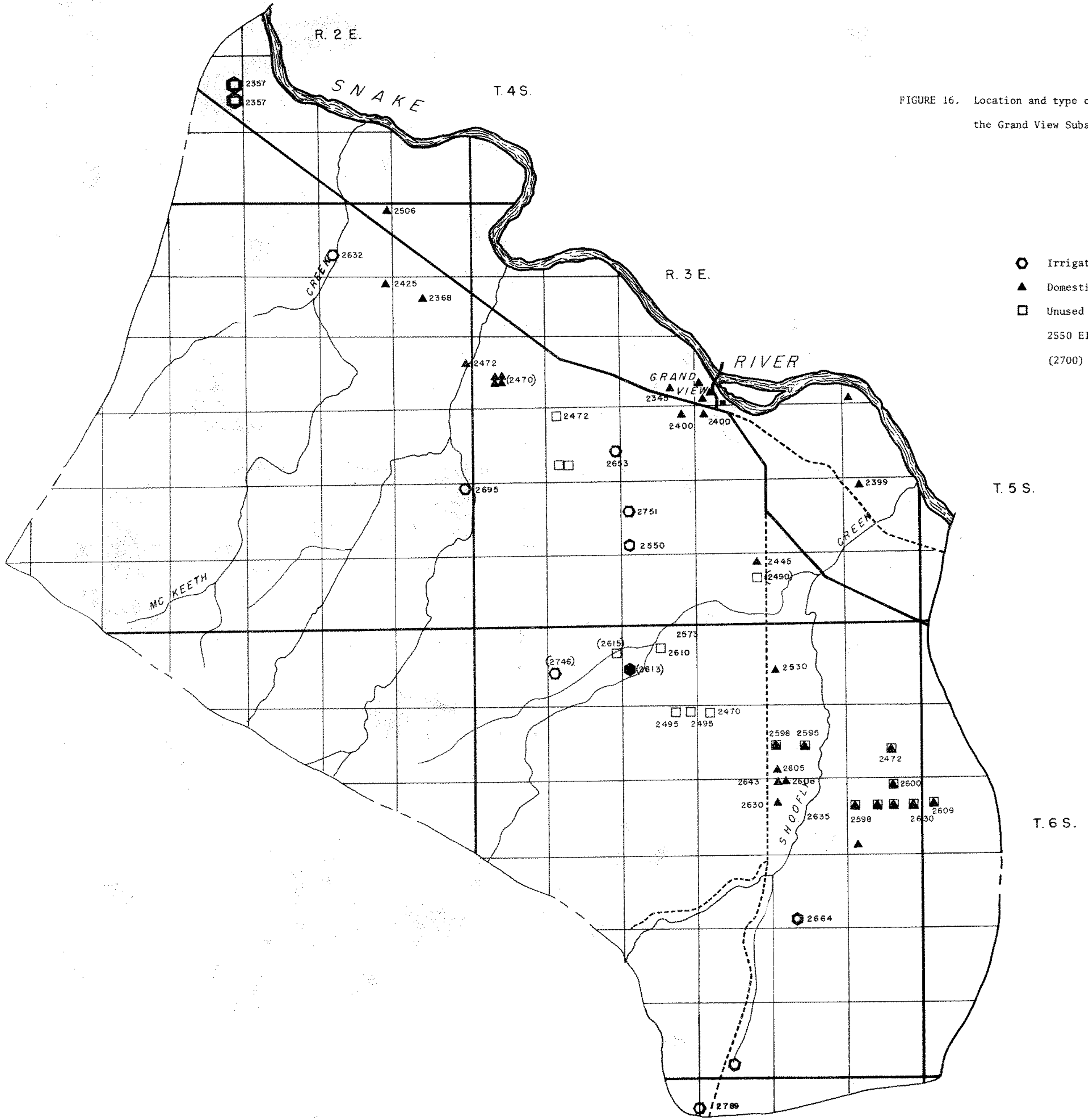
Many small diameter flowing wells were drilled in the subarea prior to 1930. Most of these wells derive small quantities of water from the Idaho Formation. The wells generally flow uncontrolled at temperatures from 80 to 100°F. These wells should be capped or plugged to prevent waste from the artesian aquifer system.

The elevation of the water surface in wells in the Grand View subarea is presented in figure 16. The maximum elevation at which wells flow in the subarea is 2,750 feet. The wells intercepting the Banbury Basalt and silicic volcanics have a higher water level elevation than wells tapping the Idaho Formation. The maximum elevation at which wells obtaining water from the Idaho Formation will flow is 2,630 feet. Different water levels are encountered with depth in both the Idaho Formation and Banbury Basalt. Many wells obtain water from both formations and thus have water levels that do not correspond to either. The direction of ground-water flow is believed to be northward in the subarea.

Declines in water levels have been reported in the Grand View subarea from wells which obtain water from both the Idaho Formation and the Banbury Basalt. Water-level declines and well interference have been reported in two wells, 1,800 and 3,600 feet deep in sec. 4 and 5, T. 6 S., R. 3 E. A 1,340-foot well (6S 3E 14bcb) has undergone 2 feet of water-level decline per year since 1962 (fig. 17). This well obtains water from the Idaho Formation. Several wells less than 500 feet in depth have reported water-level declines in the same section. The decline in water levels indicates that the present ground-water discharge through wells and natural discharge points in the area has exceeded the natural ground-water recharge. A significant portion of the present discharge is wasted through numerous old flowing wells and improperly cased artesian irrigation wells. Since the total discharge in the area is not believed to be large, the conservation of ground water presently wasted could result in a major change in the pattern of water-level decline.

The quality of ground water in the Grand View subarea varies with the depth of the wells. The deeper wells which obtain water from the Banbury Basalt and silicic volcanics have a sodium-bicarbonate type of water. The shallower water from the Glenns Ferry Formation is of calcium-bicarbonate type. The total dissolved solids content of the wells sampled in the subarea range from 190 ppm

FIGURE 16. Location and type of wells and elevation of water surface in the Grand View Subarea



LEGEND

⬡	Irrigation Wells
▲	Domestic Wells
☐	Unused Wells
	2550 Elevation of Water in Feet Above Sea Level
	(2700) Elevation of Land Surface of Flowing Wells

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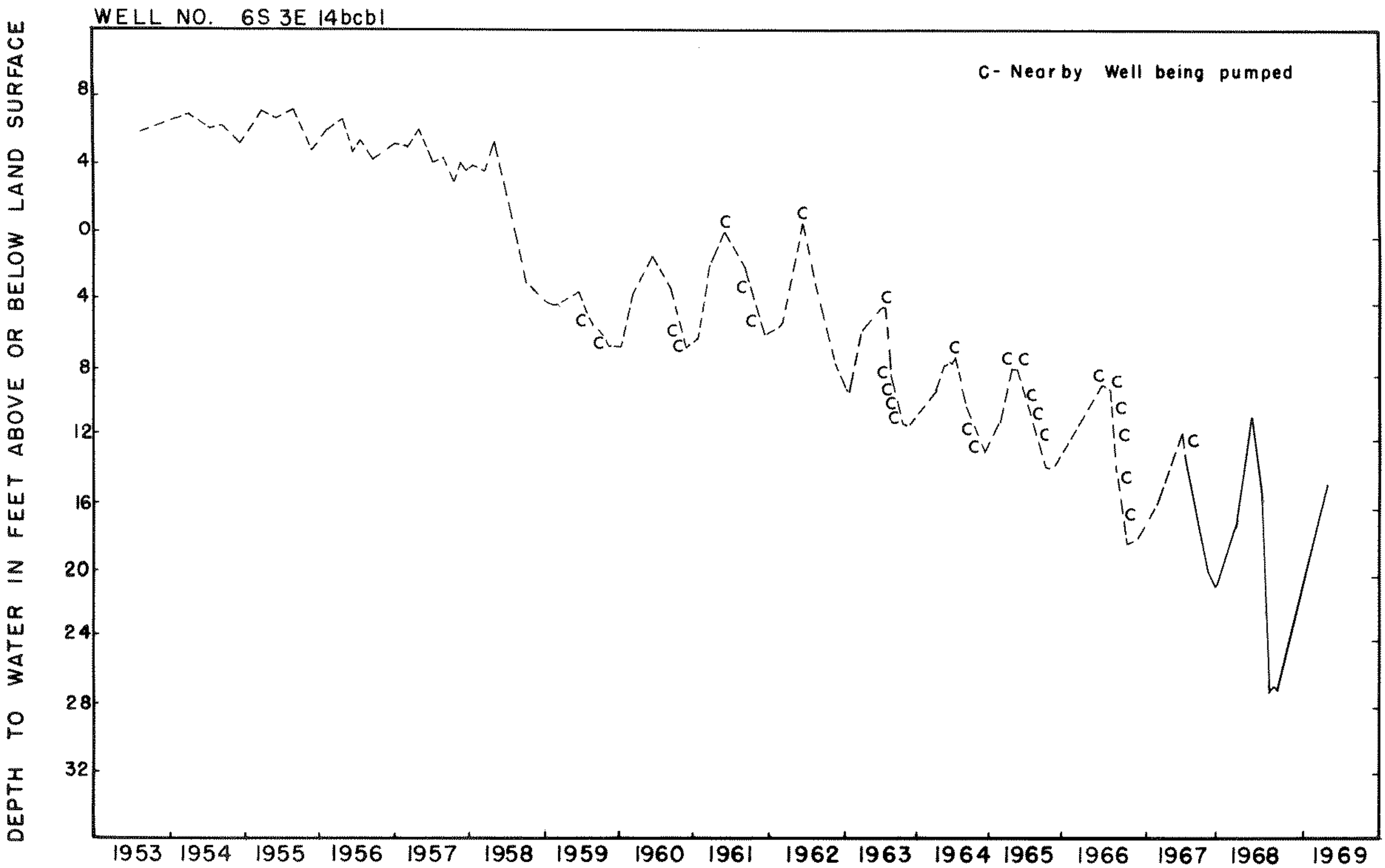

FIGURE 17. Hydrograph of well 6S 3E 14bcb in the Grand View Subarea

to 334 ppm.

Bruneau Subarea

The Bruneau subarea includes the most intensively developed areas of ground-water irrigation in the study area. Ground water in the Bruneau subarea is believed to be derived primarily from recharge in the Owyhee Mountains and Owyhee uplift. Precipitation within the subarea is not believed to be an important source of recharge to the deep aquifers.

Three geologic formations are important as aquifers in the Bruneau subarea: Tertiary Silicic Volcanics, Banbury Basalt and Glenns Ferry Formation. The silicic volcanics are encountered in a number of wells in the southern portions of Bruneau and Little valleys. A number of wells with yields exceeding 2,000 gpm derive a major portion of the water from the silicic volcanics. The aquifer is most important in the southern portion of Little Valley.

The Banbury Basalt is the most important aquifer in the subarea. Many of the wells in Little Valley and in the southern portion of Bruneau Valley derive their water from the basalt alone or in combination with the silicic volcanics. The water obtained is warm (90-100°F) and is under artesian pressure. The artesian pressure varies with the depth of the well and the penetration of the aquifers. Yields to pumped wells average 2,000 to 3,000 gpm in the Little Valley area. Well 7S 5E 7ab discharges over 3,000 gpm under artesian pressure.

The Glenns Ferry Formation is more productive as an aquifer in the Bruneau subarea than in most portions of the study area. The characteristically fine grained formation includes some sand beds in Little Valley that yield moderate supplies of water. The temperature of water derived from this formation varies from 60-95°F. The water is under artesian pressure, and rises to a maximum elevation of 2,650 feet.

The well development in the Bruneau subarea can be divided into three major categories on the basis of use: irrigation, domestic and unused flowing wells. Approximately 40 large irrigation wells have been drilled in the Little Valley area (fig. 18). Thirty of these have been drilled since 1954, the end of data collection period for the Littleton and Crosthwaite (1957) study of the Bruneau-Grand View area. The wells vary in depth from 700 to 2,100 feet and obtain water primarily from the Banbury Basalt and silicic volcanics. Most of the wells drilled since 1954 are above 2,700 feet elevation and are pumped. Approximately 30 irrigation wells have been drilled in the Bruneau Valley portion of the subarea; only 10 of which have been drilled since 1954. The yields from wells in the Bruneau Valley are generally lower than those in Little Valley. The reported discharges for irrigation wells in Bruneau Valley range from 100 to 2,500 gpm; the depths range from 300 to 1,800 feet.

A number of domestic wells have been drilled in the Bruneau subarea. Most of these wells are less than 500 feet in depth and obtain water from the Glenns Ferry Formation. Enough water for domestic purposes can be normally obtained by intersecting one or more sand strata.

Small diameter flowing wells drilled prior to 1930 constitute the third classification of wells in the Bruneau subarea. A large number of wells of this type were drilled to obtain water from the artesian aquifer systems (fig. 18). The wells generally discharge small quantities of warm (90-120°F) water continuously with only limited stock watering and irrigation use. More than 70 small diameter flowing wells were located in 1954 during a well inventory conducted in the Little Valley area by the Department of Reclamation. A large number of these types of wells are also known to exist in the Bruneau Valley.

These wells collectively represent a significant discharge from the aquifer system and should be plugged to preserve the ground-water resource.

The elevation of the water surface in wells in the Bruneau subarea is presented in figure 18. The land surface elevation of wells that flow under artesian pressure are also presented in the figure. The values indicate a general ground-water gradient from the south to the north. Different water-level elevations are found with depth. The limited data on water-level elevations indicate that lower levels are found in Little Valley and Bruneau Valley than in the surrounding areas. This would indicate that these areas are the locations of ground-water discharge.

Water-level declines have been noted in the Little Valley portion of the Bruneau subarea. The hydrograph from well 7S 5E 19ccc indicates a steady decline in water levels from 1953 to the present (fig. 19). The decline averaged 1-foot per year to 1966 and 1.5 feet per year from 1966 to the present. A second well, 7S 5E 18bc1, had an average decline of 1-foot per year for the period 1945-1966. Long term records of water levels on two wells in the Bruneau Valley did not show any significant declines or rises (fig. 19). The hydrograph data indicate that the sum of artificial and natural discharge has not exceeded the recharge to the aquifer systems in Bruneau Valley, but has exceeded the recharge in Little Valley.

The ground water in the Bruneau subarea is of sodium-bicarbonate type. The total dissolved solids range from 200 to 400 ppm. The water is generally not hard, but does have excessive concentrations of fluorides.

Indian Cove Subarea

The Indian Cove subarea includes the ground-water development along the south bank of the Snake River in the eastern edge of the study area. The

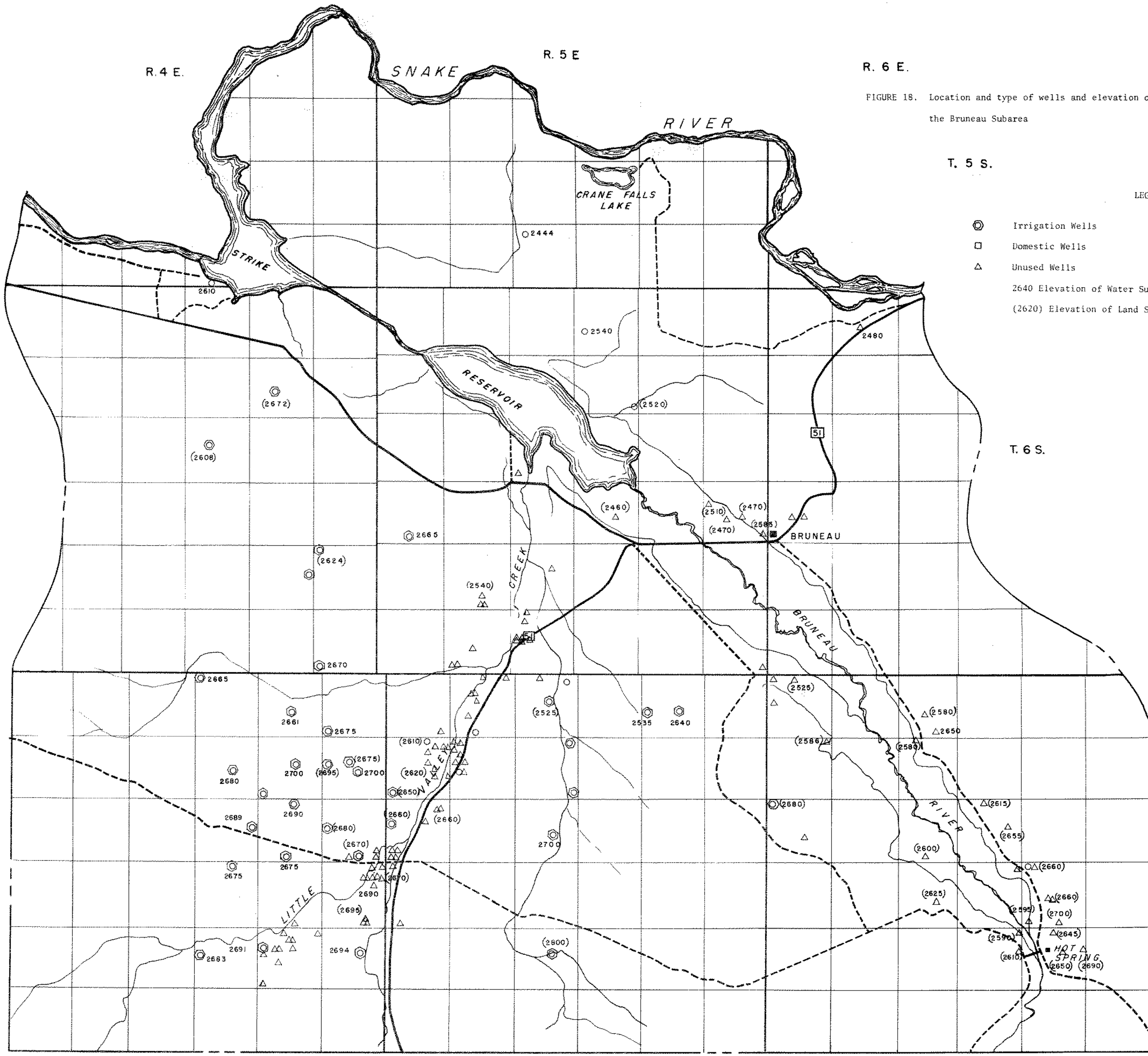

FIGURE 18. Location and type of wells and elevation of water surface in the Bruneau Subarea

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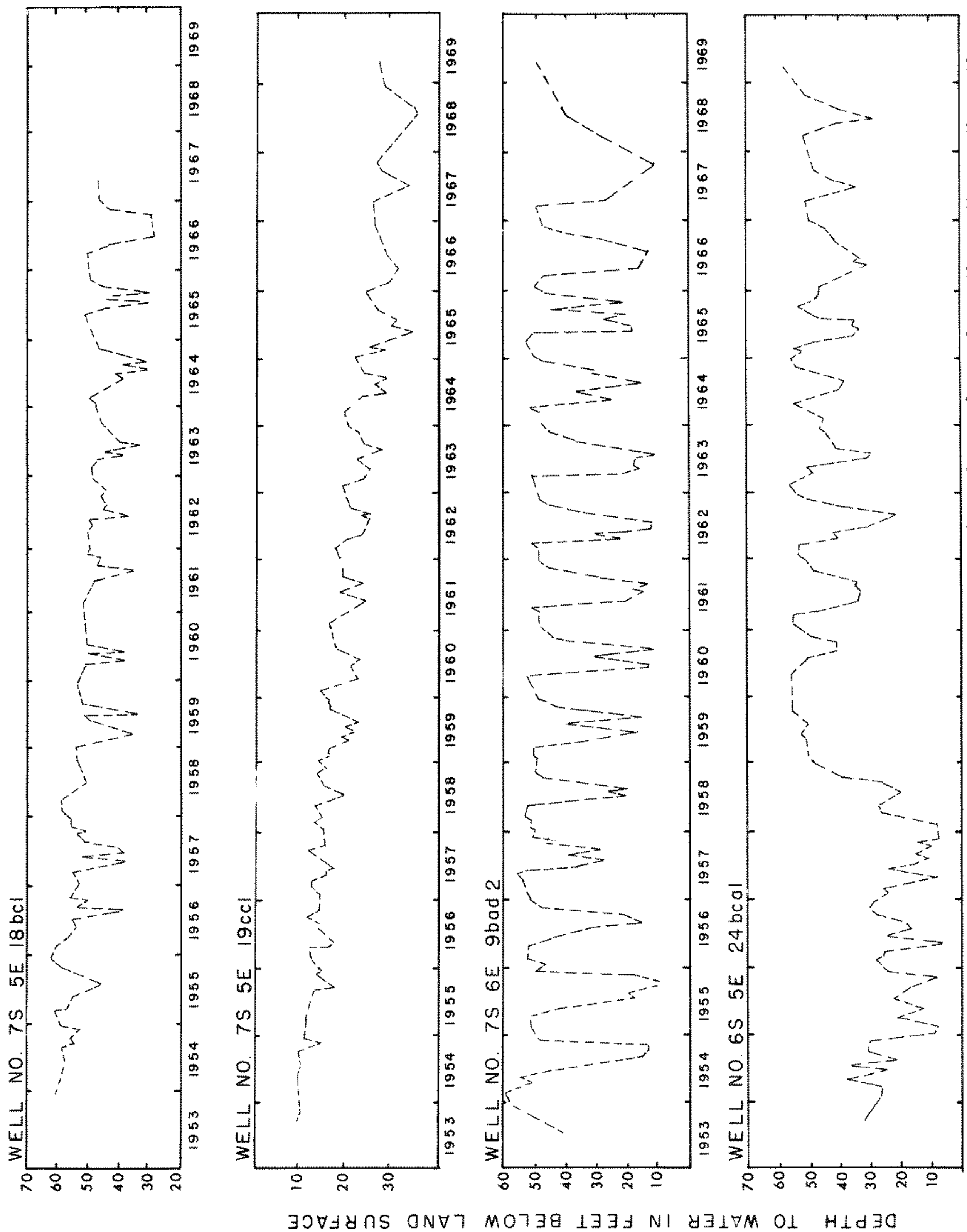
FIGURE 19. Hydrographs of wells 6S 5E 24bcal, 7S 5E 18bcl, 7S 5E 19cccl and 7S 6E 9bad1 in the Bruneau Subarea



ground-water resource in the subarea is important primarily as a source of domestic and stock watering supplies. No major irrigation supplies are derived from ground water in the area.

The deep ground water in the Indian Cove subarea is believed to be derived primarily from recharge in the Owyhee uplift. Precipitation and irrigation return flow is believed to supply some recharge to the shallow ground-water aquifer in sec. 1 and 4, T. 6 S., R. 7 E. The total quantity of water derived from this source is unknown.

Four geologic formations may be important as aquifers in the Indian Cove subarea: Tertiary Silicic Volcanics, Banbury Basalt, Glenns Ferry Formation and Recent alluvium. Silicic volcanics were encountered in only one well in the subarea at a depth of approximately 4,000 feet. The well, 6S 8E 28cd, derives water from the Glenns Ferry Formation and Banbury Basalt in addition to the silicic volcanics. The data are not available to determine the potential of the silicic volcanics as an aquifer in this area. Deep wells in the northern portion of the subarea encounter the Banbury Basalt at depths greater than 2,000 feet. Wells derive water from this formation only in this portion of the area. The wells yield only small quantities of water and are not an accurate representation of the potential production from the aquifer. The Glenns Ferry Formation is intercepted by many wells in the Indian Cove subarea. Most of these wells yield only small quantities of water. Well 6S 6E 12cc penetrated more than 800 feet of the formation and yielded only 50 gpm.

The Recent alluvium along the Snake River is an important aquifer in the Indian Cove subarea. Most of the domestic wells in the area near the river are shallow and obtain water from this material and the upper portion of the Glenns Ferry Formation. Yields to wells are generally low.

Most of the well development in the Indian Cove subarea is for domestic usage. The wells are generally less than 200 feet in depth. Wells have been drilled in excess of 4,000 feet in the subarea but produce only small quantities of water.

Two shallow wells, 6S 6E 11baa and 6S 7E 3ddc, have been operated as observation wells by the U. S. Geological Survey. The short record obtained from these wells does not indicate that any water-level decline has occurred.

The quality of ground water in the Indian Cove subarea varies with the geologic formation from which it is obtained. The well at the Bruneau Dunes State Park in sec. 12, T. 6 S., R. 6 E. obtains water from the Glenns Ferry Formation with a dissolved solids content of 920 ppm. The quality of water from the other formations in the Indian Cove subarea has not been determined.

Interrelationship of Subareas

The subareas described previously are, with the exception of one area, hydrologically interrelated. The Upper Reynolds Creek subarea, described only briefly, is considered to be a closed ground-water basin. The configuration of the granitic rock is believed to effectively prevent any ground-water outflow from the basin.

One of the most continuous aquifers in the study area is the hot, artesian system encountered in the Walters Ferry, Oreana, Grand View and Bruneau subareas. The extent to which well development in one subarea will affect another is dependent on the distance between wells and the continuity and hydrologic characteristics of the aquifer system. The continuity and hydrologic characteristics of the aquifer between the Oreana and Grand View subareas is unknown. The present development has not resulted in mutual interference between wells in different subareas. Although well development is now occurring in the area between the groups of wells in the Grand View and Bruneau subareas, the degree of hydrologic interconnection and possible mutual interference is unknown. The present knowledge of the aquifer does not suggest that a ground-water barrier or significant change in aquifer material would be present between these areas.

The shallower aquifer systems in the Glenns Ferry Formation are hydrologically connected to the deeper aquifers. Although the vertical permeability of the sediments is generally very low, a lowering of water level in the deeper aquifers will have an affect on the upper system.

The detailed hydrologic relationships between aquifers in northern Owyhee County cannot be determined at this time because of an absence of data in many portions of the area. For present administrative uses, however, the subarea boundaries noted in this report can be assumed to be effective hydrologic boundaries.

Recharge-Discharge Characteristics

Ground-water flow in the study area is believed to be from the Owyhee Mountains toward the Snake River. An important question which must be answered with respect to the ground-water resource involves the total quantity of water that flows in the system. Essentially all of the recharge to the artesian aquifer systems in the study area occurs in the Owyhee Mountains and uplands. The ground water flows through the volcanic rocks which make up much of the mountain mass to the lowland areas. Recharge to the overlying formations is accomplished by leakage upward. Some deep circulation and heating of ground water in the volcanic rocks takes place as is evidenced by the thermal qualities of almost all of the ground water in the study area. The vertical variation in artesian pressure, water temperature and water quality in the formations overlying the silicic volcanic rocks is the result of the variations in upward leakage of water from the underlying materials and the high ratio of horizontal to vertical permeability. The artesian pressure in the aquifer system is great enough to cause deep wells to flow at land surface at almost all locations near the Snake River. One hundred pounds per square inch (psi) artesian pressures have been noted at several locations.

The discharge characteristics of the aquifers appear to be the primary factors controlling the total quantity of water flowing in the system. Several possible avenues for discharge from the aquifers exist in the study area. The aquifers may (1) discharge ground water to the Snake River, (2) continue under the river and discharge in some unknown manner north of the river, and (3) discharge by leakage to the overlying formations and to land surface.

The aquifers are not believed to discharge to the Snake River from the C. J. Strike Dam site downstream in the study area. This reach of the river is underlain almost exclusively by the sediments of the Glenns Ferry Formation. The vertical permeability of this formation is known to be low. Several wells drilled near the river provide data that indicate the river is not directly connected to the ground-water system. The drillers' logs from wells 4S 2E 6ca and 3S 1E 35dac indicate that blue shale or clay (Glenns Ferry Formation) was encountered below the soil level to the bottom of the wells. The first water was encountered during drilling approximately 200 feet below the level of the river. The water levels rose in the wells to approximately 10 to 20 feet above river level. Well 5S 4E 34cb1 near C. J. Strike Dam penetrated nearly 500 feet of the Glenns Ferry Formation before encountering a significant quantity of ground water. The reach of the Snake River from C. J. Strike Dam to the western edge of the study area was traversed by boat to locate any spring discharge into the river. Electrical conductivity and water temperature were checked approximately every mile. No significant springs nor change in the temperature or electrical conductivity of the river water were noted. It is concluded from these data that the Snake River is not hydraulically connected to the ground-water system in this reach of the river. Because of the flooding of C. J. Strike Reservoir, data are not available above the dam. Since the sediments of the Glenns Ferry Formation are generally coarser in the Bruneau subarea than further downstream, a greater possibility for significant interconnection between the river and the ground-water system exists in the reach above the dam.

The second possibility mentioned for discharge from the aquifer systems in the study area, flow under the river to the north, cannot be resolved at this time. Sufficient data are not available in a major portion of the area north of the river to determine the extent of the aquifers.

The most logical explanation for discharge from the aquifer systems in northern Owyhee County is leakage to the overlying aquifers and eventual discharge by wells and evapotranspiration. Even though the vertical permeability of the sedimentary formations is low, a large area is available for upward leakage. This mechanism for discharge from the aquifer system suggests, however, that the total quantity of water moving in the aquifer system is not great. Before wells were developed, a portion of the discharge probably occurred from springs located near the mountain front where the sedimentary formations are relatively thin. The initial well development decreased or stopped this "overflow discharge." An example of this phenomenon is the hot spring connected to the artesian aquifer system in the Oreana subarea. The apparent gradient or slope of the water surface in the study area is thus primarily the effect of discharge from the aquifer system as a result of well development. A quantitative assessment of the annual yield or quantity of water recharged to the aquifer system was not made during the investigation.

Ground-Water Quality

Water quality analyses are presented in table 2 for 48 wells and springs in the northern Owyhee County study area. Eighteen samples were collected and analyzed for this study. Twenty-four samples were collected and analyzed in 1953 for the study performed by Littleton and Crosthwaite (1957) in the Bruneau-Grand View area. The remainder of the samples were analyzed either by the U. S. Geological Survey or by the State Health Department at various miscellaneous sites. The data presented in table 2 include the pH and temperature of the water, the total dissolved solids, alkalinity ($CaCO_3$) and hardness ($CaCO_3$), the cations and anions in parts per million (ppm) and the sodium-adsorption ratio (SAR). The accuracy is considered good for the older analyses but only fair for the 1968 analyses because of the imbalance of total anions and cations. Possible sources of error are the omission of silica in the analyses and the calculation of bicarbonate from the alkalinity data.

The data presented in table 2 indicate that the water is predominately of sodium-bicarbonate type. Calcium is generally the second major cation and sulfate the second major anion. The other significant anion in the analyses is fluoride.

The variations in ground-water quality in the study area are shown graphically in figure 20 by "pattern" diagrams at the locations of the wells (Hem, 1959, p. 124). These diagrams show the chemical constituents of the water in equivalents per million (epm) by a pattern plot of 3 cations and 3 anions. The quality of water in the Little Valley and Bruneau Valley areas is more

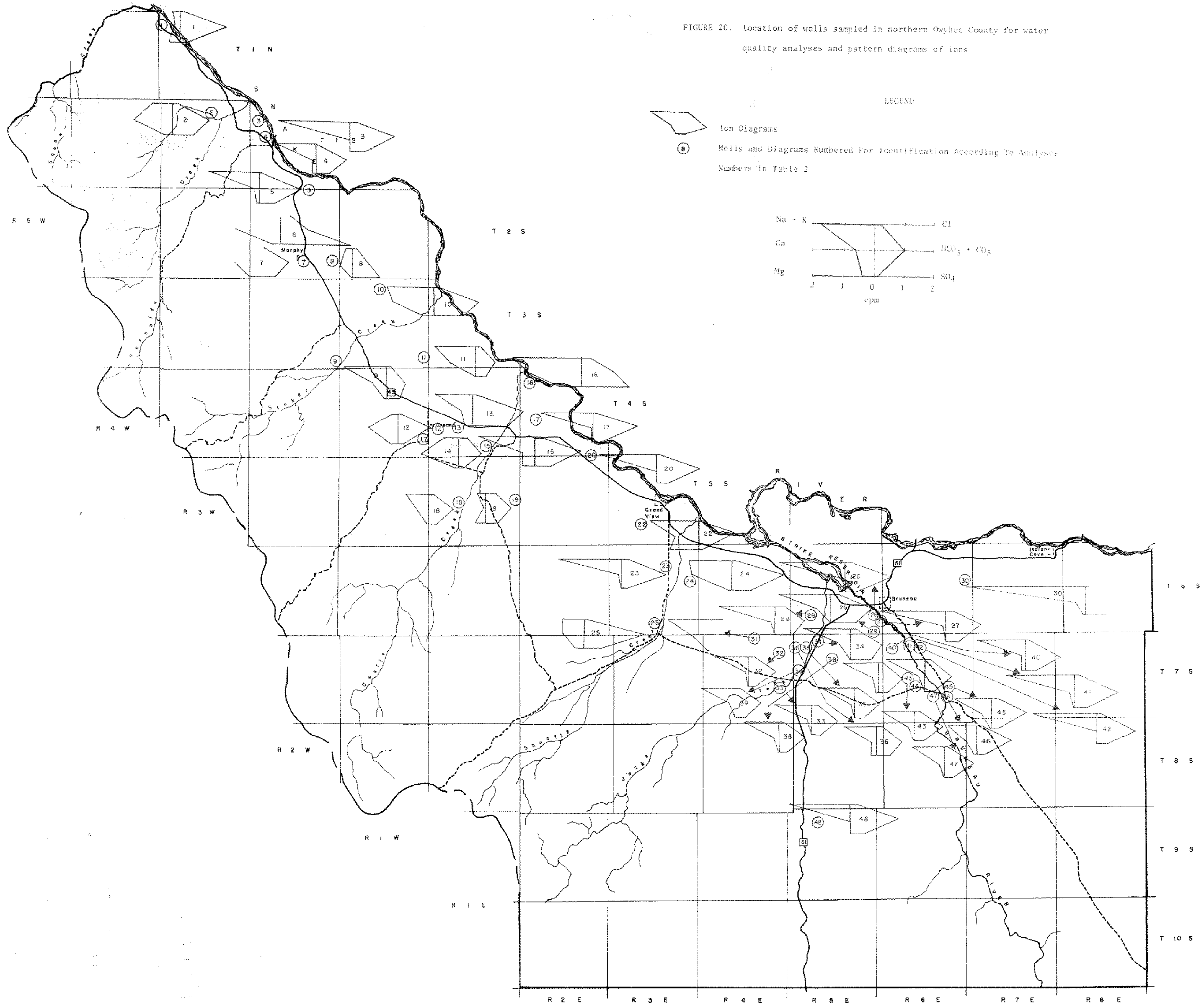
TABLE 2

WATER QUALITY ANALYSES

No.	Locations	Date	pH	Temp.	Total Dissolved Solids	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$	Ions in Parts Per Million											SAR
								Calcium Ca	Magnes. Mg	Iron Fe	Mangan. Mn	Sodium Na	Chloride Cl	Sulfate SO_4	Nitrate NO_3	Phosphate PO_4	Fluoride F	CO_3 & HCO_3	
1	1N 4W 12ac1	1-24-68	8.4	104	280	152	52	8	8	0.02	0.05	10	4	14	2.4	0.08	1.90	189	0.6
2	1S 3W 10bc1	4-25-68	8.0L	69	258	120	188	56	12	0.05	0.30	32	4	58	0.1	0.04	0.72	146	3.2
3	1S 2W 7cc1	3-19-68	8.6L	114	330	156	-	-	-	.19	-	110	15	50	-	0.01	22.20	190	-
4	1S 2W 18dcc1	3-19-68	8.4L	83	200	104	12	4	2	.23	-	66	5	43	.5	0.11	20.00	127	6.[illegible]
5	2S 2W 3ba1	2-28-68	8.9	82	220	140	20	5	2	.08	0.05	75	3	35	.7	1.04	1.50	170	7.2
6	2S 2W 26ccc	11- 7-50	-	-	525	-	198	64	9	.04	-	-	16	230	-	-	0.5	-	-
7	2S 2W 27dcd	11- 7-50	-	-	314	-	102	30	7	.04	-	-	13	51	-	-	1.1	-	-
8	2S 2W 36ba1	4-28-68	7.1	90	222	50	40	16	-	0.05	0.07	12	10	92	0.05	0.32	0.72	61	0.8
9	3S 2W 36dd1	4-25-68	7.2L	55	148	58	82	19	3	0.05	0.06	66	7	38	0.4	0.06	0.46	70	3.[illegible]
10	3S 1W 4dc1	2- 6-68	7.2	80	444	154	170	54	8	0.05	0.20	69	4	102	6.5	0.30	0.65	88	7.[illegible]
11	3S 1W 36dda1	4-25-68	7.4	70	174	64	86	33	1	0.05	0.09	62	10	37	1.6	0.04	0.01	78	2.9
12	4S 1W 36aac1	4-26-68	7.6	60	168	72	116	45	1	0.30	0.07	22	21	17	1.8	0.08	0.06	88	2.8
13	4S 1E 28bd1	3-19-68	7.6L	64	250	176	64	16	6	.23	-	63	5	115	10	0.10	.85	215	3.4
14	4S 1E 30bb1	3-13-68	7.1	59	132	106	124	40	6	0.03	0.08	8	2	14	1.0	0.56	0.39	129	1.0
15	4S 1E 34ab1	3- 1-68	8.6L	170	235	160	100	15	10	0.09	0.05	85	6	47	.8	0.56	2.30	195	4.2
16	4S 2E	4-26-68	7.6	58	398	108	244	69	17	0.20	0.20	110	15	152	1.0	0.14	1.65	131	9.[illegible]
17	4S 2E 19ac	4- 8-63	10.0	178	320	-	3	1.0	.2	.05	-	84	5.0	25	.2	-	9.2	-	20.0
18	5S 1E 21cb1	4-30-68	9.2	146	252	84	40	14	1	0.09	0.06	36	5	24	0.9	0.06	1.70	102	2.5
19	5S 1E 24ac1	4-25-68	8.8	150	250	82	40	3	8	0.05	0.02	14	15	39	1.2	0.04	1.60	155	1.0
20	5S 2E 2aa1	11-24-53	9.4	126	291	-	8	2.4	0.5	0.02	-	91	12	22	0.4	-	14.0	141	-
21	5S 2E 13ad1	11-24-53	8.8	80	825	-	44	13	2.7	.22	-	278	12	1.9	.8	-	1.2	749	-
22	5S 3E 28bc1	3-19-68	8.0	149	190	120	172	32	23	0.80	-	75	5	8	-	0.09	20.60	146	7.8
23	6S 3E 11cc2	11-24-53	9.0	94	329	-	13	3.2	1.2	-	-	98(a)	16	19	1.6	-	14	152	11.8
24	6S 3E 13ac1	11-24-53	7.5	64	334	-	159	56	4.7	-	-	42	10	65	1.3	-	.9	215	-
25	6S 3E 34cd	10- 2-68	7.0	86	298	212	102	29	7	0.08	0.20	32	5	47	0.5	0.11	0.69	258	4.4
26	6S 5E 24db1	11-23-53	8.3	77	356	-	15	4.4	.9	-	-	104(a)	13	35	3.6	-	12	185	11.8
27	6S 5E 24dd1	11-23-53	7.9	94	321	-	11	3.6	.5	-	-	100	12	38	2.9	-	24	141	13.[illegible]
28	6S 5E 29dc1	11-23-53	7.8	94	336	-	13	4.8	.2	-	-	97(a)	17	52	.6	-	18	118	11.8
29	6S 5E 36dd1	11-24-53	8.2	71	341	-	49	19	.5	-	-	87(a)	13	69	2.2	-	6.0	160	5.4
30	6S 6E 13abc	10-11-68	8.3	105	920	-	40	16	1	2.70	-	182	2	49	4.4	-	5.95	-	11.9
31	7S 4E 3ac	11-28-67	-	-	219	-	146	40	11	-	-	80	6	90	.4	-	-	-	9.[illegible]
32	7S 4E 12bd1	11-23-53	7.5	92	264	-	16	6.0	.2	.01	-	54	9.0	30	.6	-	7.0	-	5.9
33	7S 4E 24dc1	11-23-53	8.0	99	222	-	18	6.7	.3	-	-	60(a)	11	22	.8	-	10	106	6.[illegible]
34	7S 5E 5ba2	11-24-53	7.2	59	282	-	47	16	1.8	-	-	75(a)	12	68	4.0	-	7.0	102	4.[illegible]
35	7S 5E 7ab1	11-23-53	7.0	102	240	-	22	6.7	1.2	.06	-	52	9.0	20	.7	-	10	100	4.[illegible]
36	7S 5E 7ab2	11-24-53	7.8	73	228	-	37	7.1	4.8	-	-	53(a)	10	39	.8	-	6.0	100	3.[illegible]
37	7S 5E 8bb1	11-24-53	7.3	73	216	-	21	7.9	.3	-	-	58(a)	10	23	1.2	-	8.0	105	5.9
38	7S 5E 9dd1	11-24-53	7.8	92	279	-	16	5.2	.7	.03	-	57	7.0	20	1.0	-	10	115	6.[illegible]
39	7S 5E 18bc1	11-24-53	8.2	92	294	-	18	6.4	.4	.32	-	50	8.0	18	.8	-	9.0	108	5.2
40	7S 6E 7aa1	11-24-53	9.4	90	299	-	23	5.6	2.1	-	-	78(a)	12	26	.1	-	12	100	7.[illegible]
41	7S 6E 9ba1	11-23-53	9.1	120	370	-	16	4.0	1.4	-	-	109(a)	12	31	.2	-	22	152	11.9
42	7S 6E 9ba2	11-23-53	9.2	120	271	-	12	2.4	1.4	.04	-	100	10	30	.5	-	24	135	12.9
43	7S 6E 16cd1	11-23-53	7.6	100	222	-	29	10	.9	-	-	55(a)	9.0	20	1.6	-	7.0	117	4.9
44	7S 6E 21db1	11-23-53	8.2	104	236	-	25	7.9	1.4	-	-	63(a)	10	21	.8	-	12	114	5.4
45	7S 6E 23ca1	11-23-53	8.6	115	261	-	44	14	2.1	-	-	-	11	21	1.6	-	7.0	130	3.8
46	7S 6E 23dc1	11-23-53	8.2	105	234	-	55	17	3.1	-	-	48(a)	9.0	19	1.9	-	4.0	137	2.8
47	7S 6E 27aa1	11-23-53	7.2	117	237	-	28	9.1	1.2	-	-	51	9.0	17	1.3	-	10	110	4.2
48	9S 5E 4	4- 8-63	9.4	-	303	-	2	1.0	-	1.9	-	92	13	26	.2	-	20	-	25.[illegible]

(a) Sodium and Potassium

FIGURE 20. Location of wells sampled in northern Owyhee County for water quality analyses and pattern diagrams of ions



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consistent than that found in the remainder of the area. The water is of sodium-bicarbonate type with a lesser amount of sulfate. The percentages of calcium and magnesium are very small. Lesser amounts of sodium and bicarbonate are found in Little Valley and Upper Bruneau Valley than in Lower Bruneau Valley. These changes may be related to the Hot Spring fault and the change in thickness of the sediments of the Idaho Formation (Littleton and Crosthwaite, 1957). The same chemical characteristics are common to the deep wells south and west of Grand View in the Grand View subarea. Further to the west in the Oreana subarea, several of the hot, artesian wells obtain water with similar chemical characteristics. Three wells near Walters Ferry in the Walters Ferry subarea also had similar chemical characteristics.

A large percentage of wells sampled in the western portion of the study area had water quality characteristics different from the pattern described above. Wells penetrating the Glenns Ferry Formation south of Grand View and near Oreana had a calcium-bicarbonate type water. The predominance of calcium may be the result of concentrations of calcium in evaporite deposits associated with the Glenns Ferry Formation. Several wells closer to the river in the Oreana subarea have similar characteristics except that sodium is the major cation. More base exchange of sodium for calcium and magnesium probably has occurred by this point. The wells near the Snake River also had a greater concentration of sulfate, which also may be associated with the Glenns Ferry Formation. Calcium-bicarbonate type water is characteristic of the well in the extreme western portion of the study area. This well obtains water from the Poison Creek Formation.

The previous discussion indicates that sodium is the predominant cation and bicarbonate the primary anion of ground water in the study area. Contours of the concentrations of sodium in epm are presented in figure 21. The concentrations of sodium in the ground water generally increase from the south to the north, the direction of ground-water flow. This pattern is expected because of two factors: sodium is leached from the rock material by the ground water, and sodium replaces either calcium or magnesium in the water by base exchange. The lowest concentrations of sodium would thus be expected nearest the mountain front. The bicarbonate concentrations are generally lower near the mountain front and increase towards the river. The area of lowest bicarbonate concentration is in the Bruneau subarea south of the Hot Spring fault. The bicarbonate concentration is important as it is needed in the replacement of calcium and magnesium by sodium. The concentration of calcium is generally higher in the cold water aquifers in the subarea. This pattern might be explained by the increased rate of base exchange of sodium for calcium with increased temperature. The pattern of fluoride concentrations are presented in figure 22. The general areas of high concentrations may be associated with the silicic volcanic rocks and the movement of warm water from this formation. The concentrations of fluoride shown are some of the highest in the nation. The concentrations of the total dissolved solids are presented areally in figure 23. Most of the values are below 400 ppm. The samples obtained from the sand aquifer of the Glenns Ferry Formation near Oreana have concentrations of total dissolved solids less than 200 ppm.

Two of the characteristics that are most important in determining the quality of water for irrigation purposes are total dissolved solids and relative proportion of sodium to other cations. All but one of the samples obtained in northern Owyhee County have lower levels of total dissolved solids than the recommended maximum (Richards and others, 1954, p. 70). Thus, from

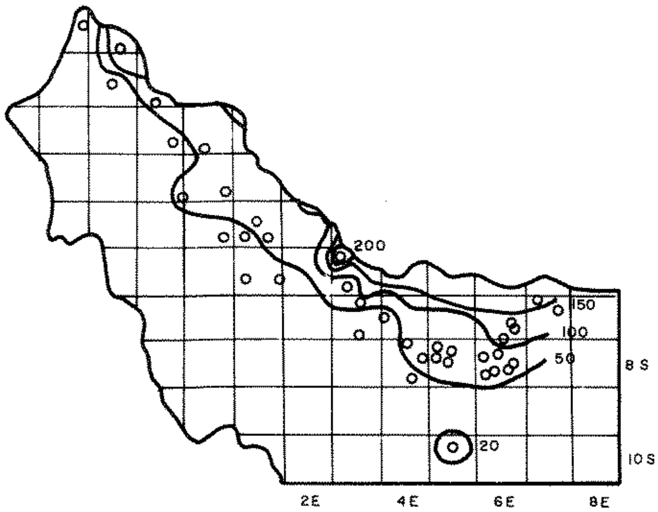


FIGURE 21. Contours of concentrations of sodium in epm in northern Owyhee County

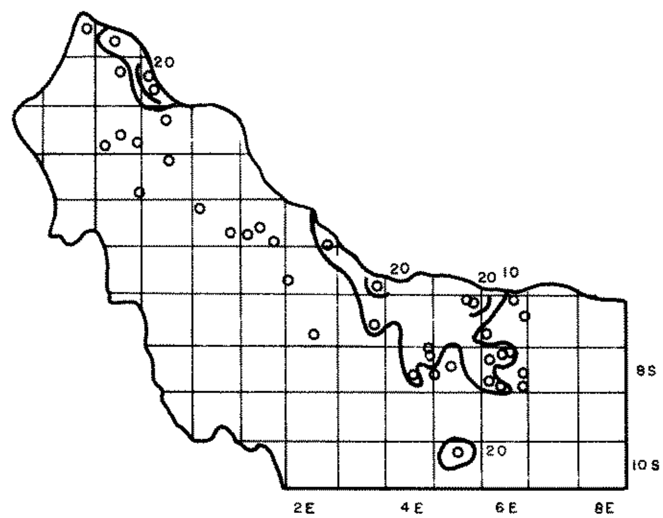


FIGURE 22. Contours of concentrations of fluoride in epm in northern Owyhee County

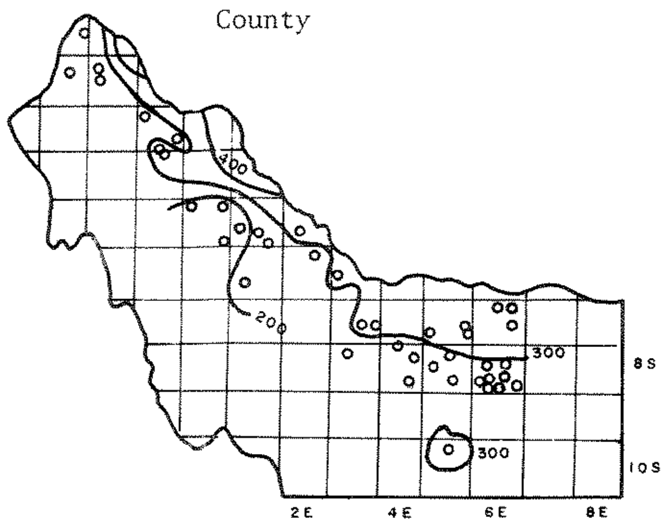


FIGURE 23. Contours of total dissolved solids from samples in northern Owyhee County

this criteria, the ground water in the study area is acceptable for irrigation purposes.

The suitability of ground water for irrigation purposes depends in part upon the characteristics of the soil to which it is applied. The sodium-adsorption ratio (SAR) is an empirical relationship relating to the adsorption of sodium by the soil to which it is being added (Richards and others, p. 72). The alkali hazard involved in the use of water for irrigation is determined by both the absolute and relative concentrations of the cations. If the proportion of sodium is high, the alkali hazard is high. If calcium and magnesium predominate, the alkali hazard is low (Richards and others, 1954, p. 22). A ratio of these ions is useful as an index of the sodium hazard of the water. The SAR is defined as follows in epm:

$$SAR = \frac{Na^{++}}{\sqrt{(Ca^{++} + Mg^{++})/2}}$$

Irrigation waters may be classified using the SAR value and either electrical conductivity or total dissolved solids. Since electrical conductivity values were not obtained in the data collected during 1968, total dissolved solids are used on the ordinate of the graph. The diagram for the classifications of irrigation waters, presented by Richards and others (1954, p. 80), is presented for the study area in figure 24. A ratio of total dissolved solids to electrical conductivity of 0.64 (an average suggested by Richards and others, 1954, p. 80) was used to derive the diagram.

Sixty-nine per cent of the wells sampled in northern Owyhee County had a low sodium or alkali hazard. Twenty-two per cent of the samples had medium sodium hazard; six samples had high to very high sodium hazard. Most of the

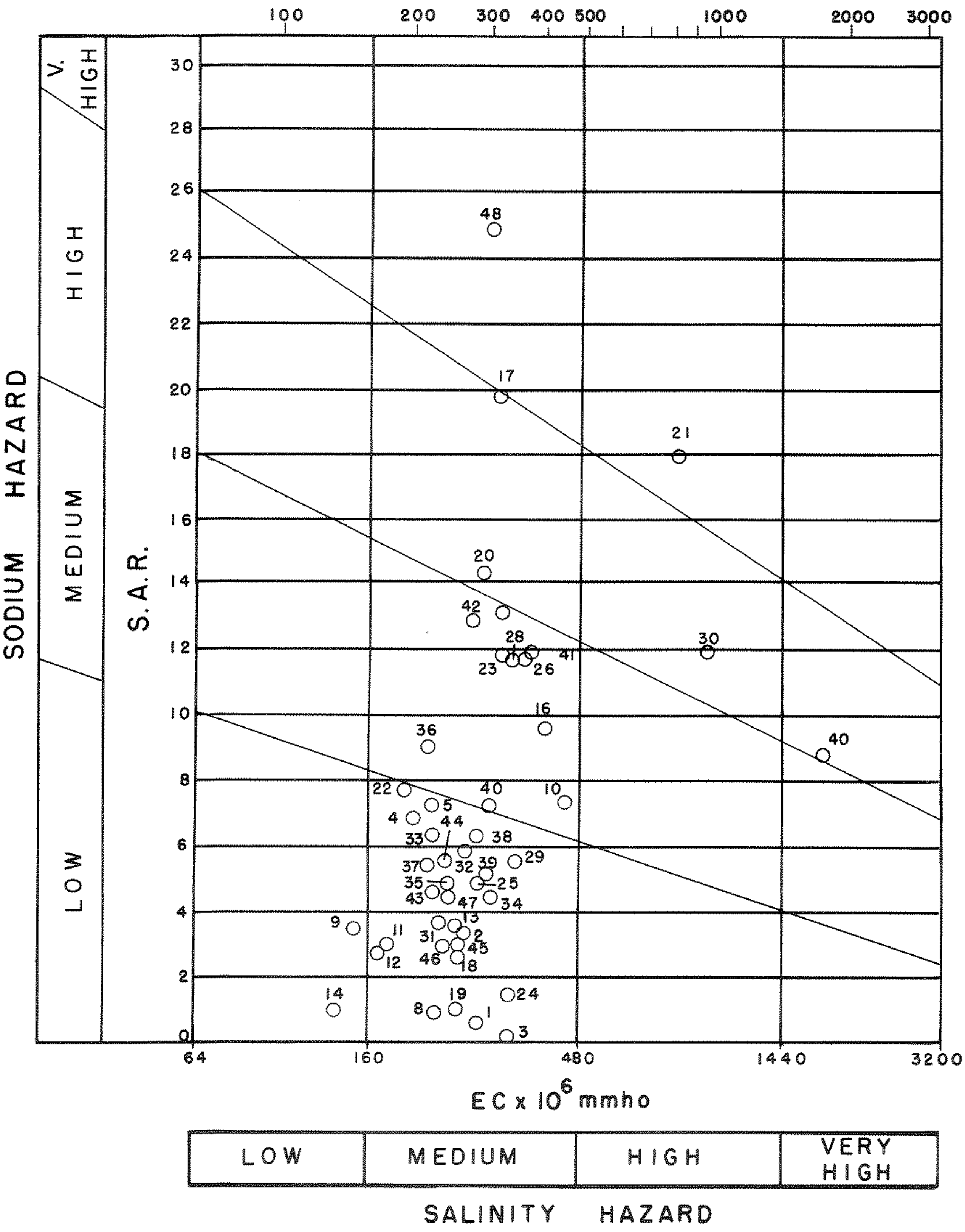


FIGURE 24. Suitability of water for irrigation in northern Owyhee County

wells sampled had a medium salinity hazard. These classifications are based on an average soil with respect to texture, infiltration, drainage, and other factors. Medium salinity water can be used if a moderate amount of leaching occurs. The medium and high sodium water can only be effectively used in coarse grained soils with good permeability. Many of the soils in the study area are fine grained and only limited leaching occurs. Care should be taken in areas where ground water with a high sodium content is used for irrigation to prevent alkali accumulation.

Thirty-five of the wells sampled in the Owyhee County study area do not meet the U. S. Public Health Service drinking water standards (1962) because of an excess of fluoride. Almost all of the wells sampled in the study area meet these standards with respect to total dissolved solids (500 ppm) and concentration of iron, sulfate, chloride, and nitrate.

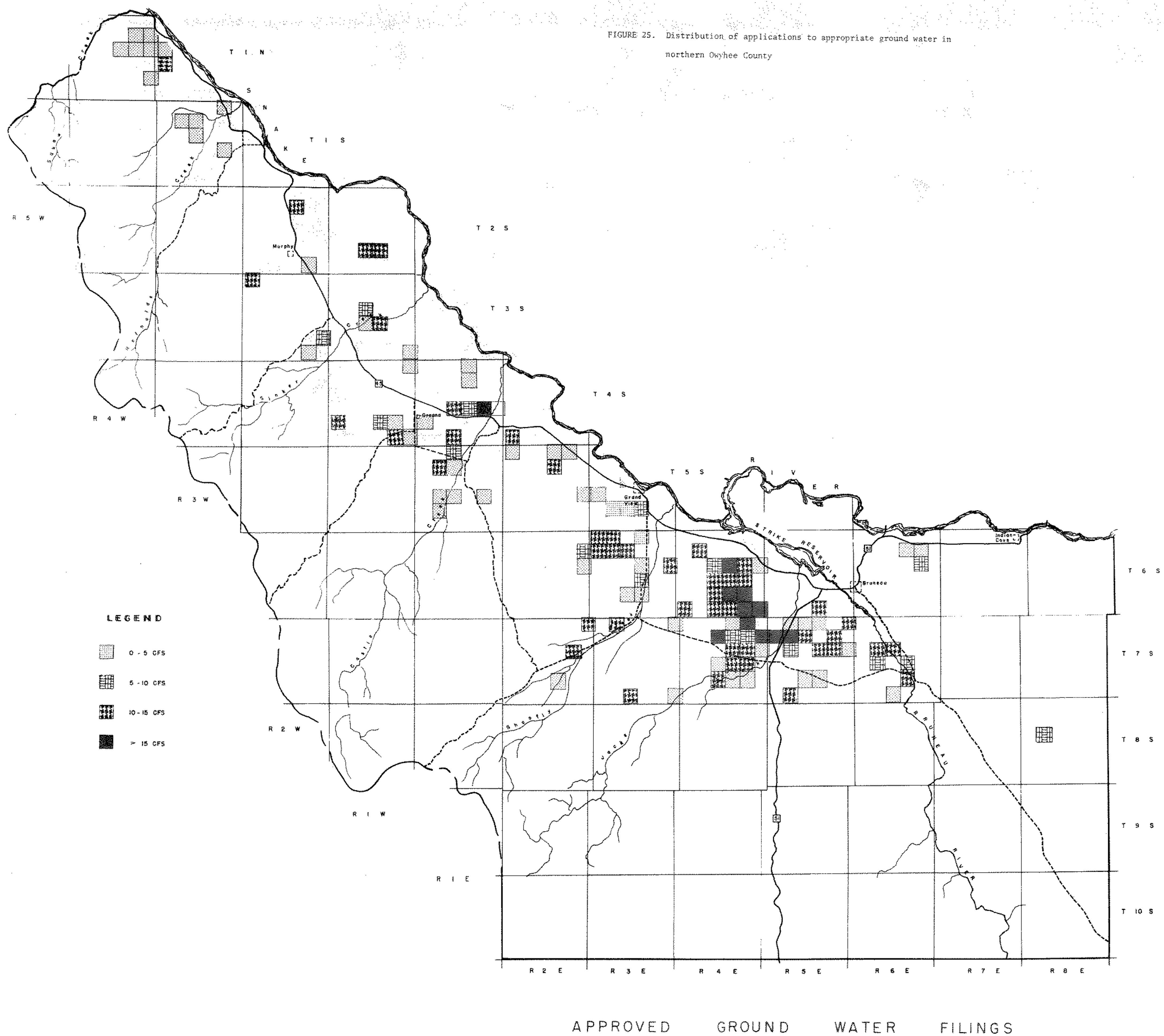
WATER RIGHTS

The Department of Reclamation has on file 253 permits or licenses for the withdrawal of ground water within the study area. These indicate a potential discharge of 1,049 cfs for domestic uses and the irrigation of 58,500 acres. The distribution of ground-water filings by section are shown in figure 25.

The largest grouping of ground-water filings is in the Bruneau subarea. A potential discharge of 300 cfs exists in a 29 square mile area in western Little Valley. Filings are also grouped in the Shoofly Creek valley, Castle Creek-Oreana area and in the western portion of the study area.

No restriction on ground-water filings is presently in force in the northern Owyhee County study area. New lands are being opened in areas where a ground-water potential exists. Twenty-five applications to divert ground water were approved in 1967 and forty-four in 1968 in the northern Owyhee

FIGURE 25. Distribution of applications to appropriate ground water in northern Owyhee County



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County study area (Ralston, 1968 and 1969).

SUMMARY AND CONCLUSIONS

The occurrences of ground water vary widely in the study area. The Tertiary Silicic Volcanics are believed to be important as aquifers only in the Bruneau and Little Valley areas. Although wells have encountered the formation in other portions of the study area, data are insufficient to determine its true importance as an aquifer. More permeable zones within this formation may hold a large potential for future well development. The Poison Creek Formation is important as an aquifer only in the western half of the study area. The yields are generally low from this formation. The Banbury Basalt is very important as an aquifer in the Bruneau, Little, Shoofly and Castle Creek valleys. Further to the west, the formation is encountered only at scattered locations. The formation may be very permeable or relatively impermeable depending upon the number of open joints and fractures in the rock. The Glenns Ferry Formation is the most widespread aquifer in the study area. The formation generally has a low permeability but supplies enough water for domestic and small irrigation usage. Sand beds in the Glenns Ferry Formation near Oreana provide good aquifers and yield sufficient quantities of water for irrigation purposes. The Recent alluvium along the Snake River is important as an aquifer at several locations in the study area. Shallow wells near Grand View and Indian Cove derive domestic supplies from this material.

Almost all of the ground water in the study area is derived from precipitation on the Owyhee Mountains and uplift. Heating of a portion of the ground water occurs at great depths, and causes most of the ground water in the study area to be thermal. The primary mechanism for discharge from the aquifer system in the Tertiary Silicic Volcanics and Banbury Basalt is believed to be seepage upward into the overlying formations. The Snake River is not believed to be hydraulically connected to the general aquifer system from the C. J. Strike Dam downstream to the edge of the study area. The total recharge to the aquifers is thus believed to be limited in quantity.

Significant declines in water levels are occurring in three portions of the study area: Little Valley in the Bruneau subarea, Shoofly Valley in the Grand View subarea and Castle Creek valley in the Oreana subarea. Well hydrographs indicate that the water level is lowering at the rate of one to one and one-half feet per year in the aquifers in the Banbury Basalt and silicic volcanics in Little Valley. Declines at a similar rate have occurred in the aquifer in the Banbury Basalt in Shoofly Valley. The water levels in wells tapping the hot, artesian aquifer in the Banbury Basalt and Poison Creek Formation in the Castle Creek valley have lowered approximately 90 feet since 1959. The details of the decline are not known although 12 feet of change was noted in a well from spring, 1967 to spring, 1968. Some decline in water levels may also be occurring in the western portion of the study area along the Snake River.

The water levels in the above mentioned areas are dropping because the total discharge from the aquifer system is exceeding the total recharge. The total discharge is made up of the natural discharge from the aquifer system and the artificial discharge by wells. The discharge from wells causes a lowering of water levels and thus a decrease in natural discharge. If well development is initiated and maintained at a level below the recharge rate to the aquifer system, the water levels will decline only to the point where the recovered natural discharge is equal to the well discharge and then tend to stabilize. However, if the well discharge exceeds the recharge, the water levels will continue to lower and not stabilize. The relative magnitudes of recharge and well discharge in the areas of decline in northern Owyhee County were not determined as part of this study. One remedial measure that should be undertaken in these areas is to conserve the water by plugging or capping all the unused wells and turning off the flowing wells during the nonirrigation season.

The ground-water quality in much of Owyhee County is only fair for irrigation because of a medium salinity hazard. Such water can only be used on lands where a moderate amount of leaching occurs. The soils in the study area are generally fine grained, limiting the amount of leaching. The ground-water quality is also only fair for domestic uses in some areas because of high fluoride contents.

RECOMMENDATIONS

Pending further study, all of the northern Owyhee County study area should remain open for future ground-water development. Several areas have undergone water-level decline, however, and should be studied for possible critical designation at a later date. The Little Valley area in the Bruneau subarea should be studied first. This study should include a water budget for the estimated limits of the aquifer system to provide quantitative information for water rights administration. The areas of decline in the Shoofly and Castle Creek valleys should subsequently be studied in a similar manner.

An intensive program of water conservation should be initiated in the study area. This program should include both education and enforcement. The primary objectives of this program should be the plugging or capping of uncontrolled and improperly cased artesian wells and the enforcement of irrigation seasons and usages of appropriated quantities.

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